<u>Effect of Health on Human Capital Accumulation in Ethiopia, India, Peru and Vietnam: A Quantile Regression Approach</u>

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Human capital accumulation is the end and means of economic development. Scaling up of child nutrition program in the developing countries has great impact on human capital development, labour productivity and economic growth (Belli et al., 2005, Stenberg et al., 2014, Sahn and Alderman, 1988, Hoddinott et al., 2008). For given education level, adult height has positive effect on wage earning among manual labour (Strauss and Thomas, 1998, Thomas and Strauss, 1997). Childhood Nutritional is associated with adult wage, not only through physical health but also through the cognition development and schooling (Haas et al., 1995, Hoddinott et al., 2008, Lozoff et al., 2006, Grantham-McGregor et al., 2007).

During mid-childhood aged 6-8 years a child attain the maximum height and weight growth, concomitant cognition development enables the child for logical thinking and education attainment (Crookston et al., 2013). Studies have shown that child has potential to grow and recover from the stunting during childhood (Adair, 1999, Johnston and Macvean, 1995, Belli et al., 2005, Fink and Rockers, 2014). In the subsequent adolescent aged 14-15 years both the physiological and mental growth becomes stagnant (Eccles, 1999). On the contrary, nutritional intervention up to 3 years has the maximal effect on human capital development in the adulthood (Adair et al., 2013, Stein et al., 2010, Schroeder et al., 1995). All the above studies have established the effect of childhood health status on human capital formation, but none of them have investigated that differential impact of health improvement on human capital formation. In this context present study investigate the effect of health on human capital accumulation.

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Objective: Effect of conditional linear growth (CLG) and conditional relative weight gain (CRWG) on the different level of the distribution of education and health human capital.

Data and Method

Study used Young Lives Study (YLS) of four prospective mid-childhood aged (7-8 years) cohorts from Ethiopia (N=1000), India (Andhra Pradesh N=1008), Peru (N=714) and Vietnam (1000) recruited in 2002 followed up at adolescents (14-15 years) in 2009-10. YLS is conducted by University of Oxford, UK. Applying sentinel sampling approach 150 households (100 younger and 50 older child cohorts) randomly selected from each of the 20 sites from both rural urban area. Although study is not national representative but it covers wide range of socio-economic, cultural, political and geographical perspectives. For details of the object and sampling design (Wilson et al., 2006, Barnett et al., 2012) The prospective survey design enables the life course dynamics of health on human capital (Barnett et al., 2012).

Exposure variable: Studies have shown that faster weight gain without concomitant linear growth poses heath risk during adolescent and adulthood (Hales and Ozanne, 2003, Ong, 2007, Victora et al., 2001), therefore we have separated the effect of linear growth and weight gain. CLG between mid-childhood and adolescent is the height in 2009 adjusted for the height and weight in 2002. CRWG between mid-childhood and adolescent is the present (2009) weight adjusted for present height and previous (2002) weight and height (Adair et al., 2013). We have calculated the CLG and CRWG separately for male and female by country.

Outcome variables: Other than years of schooling, education human capital includes child's receptive language skills measured by Peabody Picture Vocabulary Test (PPVT) and performance in standardized math test developed in YLS (Fink and Rockers, 2014, Jongsma, 1982, Cueto and León, 2012). Health human capital is measured terms of height, weight/height^2 (BMI) score, height-for-age z-score and weight-for-height z-score (WHO, 2006, Cole et al., 2000).

Assuming the linear association between health and human capital we have used cluster fixed effect linear regression. Again, applying cluster fixed effect quantile regression we have estimated the varied effect of CLG and CRWG on the measures of human capital's distribution. In the multivariate analysis we have controlled the social-demographic and economic status of the adolescent as these intermediate the effect of health on human capital accumulation (Maluccio et al., 2009, Hoddinott et al., 2005, Grantham-McGregor et al., 2007).

Result

Table 1 shows that value of health and education human capital. There is significant difference education human capital across countries. Only 17% Ethiopian adolescent had completed secondary education compared with 83% in Vietnam. Mean years of schooling at mid-childhood in 2002 was highest in India (3.4 years) whereas among the adolescent average years of schooling was highest in Vietnam (8.1 years). Vietnam had the highest PPVT score (136) and math score (18) both whereas Peru (97) and Ethiopia (5) were at the bottom of score respectively. Average height at both the time periods was almost in same range in all four countries, whereas average weight varies across the countries. Over the period of time average BMI score has increased across all countries. During the study period, 50-54% and 44-46% adolescent experienced the positive CLG and CRWG respectively, over the mid-childhood.

Table 2 shows that CLG has significant positive effect on education human capital accumulation in Ethiopia, Peru, and Vietnam except only on PPVT score and math score in India. All measures of health human capital measures are significantly associated with CLG. On an average one c.m. of CLG is expected to increase the BMI score by 0.062 to 0.152 points, z-hfa score by 0.121 to 0.127 points and z-bmi score by 0.030 to 0.076 points. Odds of being stunted or underweight reduces with the increase in CLG. Similarly, CRWG has significant positive effect on education and health human capital accumulation. On average one k.g. of CRWG is expected to increase the PPVT score by 0.204 to 0.749 points and math score by 0.076 to 0.143 points. CRWG has significant positive effect on health human capital accumulation in all four countries. At mean

one k.g. increase in CRWG is associated with 0.733 to 1.115 c.m. height, 0.098 to 0.210 points BMI score, 0.119 to 0.188 points z-hfa score and 0.060 to 0.95 z-bmi score.

Quantile regression coefficient in Table 3 shows the varying effect of CLG and CRWG on distribution of education and health human capital on pooled sample. Result shows that positive gradient of CLG and CRWG decreases at higher level of years schooling and PPVT score distribution; and increases at higher level of math score. Between the lowest 10th quantile to the 90th quantile, regression coefficient of years of schooling on CLG and CRWG decrease from 0.050 to 0.021 and 0.043 to 0.016 respectively. Similarly, β-coefficient of PPVT score on CLG and CRWG decreased from 0.514 to 0.164 and 0.373 to 0.138 respectively between 10th quantile to 90th quantile. Regression coefficient of BMI score on CLG and CRWG increased from 0.071 to 0.109 and 0.140 to 0.188 respectively between 10th quantile to 90th quantile of BMI score. Effect of CRWG on z-hfa score increased from 0.147 at the lowest 10th quantile to 0.162 at the highest 90th quantile of the z-hfa score distribution.

Conclusion

Study shows that conditional linear growth and relative weight gain during mid-childhood and adolescent has significant positive effect on education and health human capital accumulation. But the quantile regression result shows that effect of health and human capital formation is similar across the level of distribution of human capital measure. From the result it can be inferred that mid-childhood nutritional intervention with positive discrimination in favor of the severe stunted or underweight child will attain the maximum gain in human capital accumulation and resultant economic growth.

Table 1: Value of health and education human capital and its determinants

	Ethiopia		India		Peru		Vietnam		Pooled	
	2002 (N=1000)	2009 (N=974)	2002 N=1008	2009 N=976	2002 N=714	2009 N=678	2002 N=1000	2009 N=976	2002 (N=3772)	2009 (N=3604)
% Secondary education*	NA	16.5(2.9)	NA	67.5(2.4)	NA	65.2(3.7)	NA	83.4(3.6)	NA	57.6(2)
Mean years of schooling	1.3(0.1)	5.1(0.3)	3.4(0.1)	6.7(0.2)	2.3(0.1)	7.2(0.2)	2.7(0.1)	8.1(0.1)	2.4(0.0)	6.8(0.1)
Mean PPVT score	NA	154(6.4)	NA	124(2.6)	NA	96.9(2.0)	NA	166(3.3)	NA	136(2.3)
Mean Math score	NA	5.2(0.4)	NA	8.7(0.4)	NA	13.1(0.6)	NA	17.6(0.8)	NA	11.0(0.4)
Mean height (cm)	118(0.5)	155(0.6)	118(0.3)	153(0.4)	119(0.5)	154(0.6)	119(0.4)	155(0.4)	118(0.2)	154(0.3)
Mean weight (kg)	19.1(0.4)	40.5(0.6)	19.5(0.1)	41.3(0.5)	23.7(0.2)	50.3(0.6)	20.1(0.2)	44.2(0.5)	20.4(0.1)	43.6(0.4)
Mean BMI score	13.7(0.3)	16.8(0.2)	13.9(0.1)	17.6(0.2)	16.8(0.1)	21.1(0.2)	14.2(0.1)	18.4(0.1)	14.5(0.1)	18.2(0.1)
% Stunted (z-hfa<-2)	32.7(2.9)	29.9(2.3)	33.4(2.2)	36.2(1.9)	27.9(2.3)	26.2(3.1)	29(2.7)	24.5(2.4)	31.0(1.3)	29.5(1.2)
% Underweight (z-bmi<-2)	27.9(6.4)	42.1(3.2)	26.3(1.2)	27.8(1.8)	1.0(0.4)	1.3(0.5)	18.5(1.4)	13.4(1.5)	19.6(1.7)	22.9(1.4)
Mean z-hfa score	-1.5(0.1)	-1.4(0.1)	-1.6(0.1)	-1.7(0.0)	-1.4(0.1)	-1.5(0.1)	-1.5(0.1)	-1.4(0.1)	-1.5(0.0)	-1.5(0.0)
Mean z-bmi score	-1.6(0.3)	-1.7(0.1)	-1.4(0.0)	-1.3(0.1)	0.5(0.0)	0.3(0.1)	-1.1(0.1)	-0.9(0.1)	-1.0(0.1)	-1.0(0.1)
% achieved +ve CLG (2002-09)	50.8(3.3)		51.2(2.2)		52.4(2.2)		53.8(2.1)		52.0(1.3)	
% achieved +ve CRWG (2002-09)	45.7(3.4)		44.2(2.4)		46.0(2.8)		46.3(2.0)		45.5(1.4)	

*Note: Standard Error in parenthesis; *3+ and 8+ years of schooling for the child age of 8 years and 15 years respectively*

Table 2: Linear regression coefficient and logistic regression odds ratio of conditional linear growth and conditional relative weight gain on health and education human capital measures, adjusted for the background covariates, Ethiopia, India, Peru, Vietnam, and pooled, 2009

Association between conditional linear growth and education human capital accumulation					
	Ethiopia	**India**	**Peru**	**Vietnam**	**Pooled**
Secondary education (OR)	1.121***	1.022	1.052**	1.054**	1.054***
	(1.077,1.166)	(0.988,1.058)	(1.006,1.1)	(1.005,1.105)	(1.035,1.075)
Years of schooling (β-Coeff.)	0.073***	-0.004	0.030	0.033***	0.042***
	(0.051,0.095)	(-0.049,0.041)	(-0.006,0.067)	(0.012,0.054)	(0.027,0.058)
PPVT score (β-Coeff.)	0.577***	0.445*	0.255**	0.933***	0.504***
	(0.171,0.983)	(-0.057,0.948)	(0.007,0.504)	(0.613,1.254)	(0.309,0.699)
Math score (β-Coeff.)	0.083***	0.092**	0.049	0.200***	0.095***
	(0.038,0.127)	(0.017,0.168)	(-0.038,0.137)	(0.104,0.297)	(0.060,0.130)
Association between conditional linear growth and health human capital accumulation					
Height (β-Coeff.)	0.952***	0.944***	0.958***	0.957***	0.959***
	(0.886,1.018)	(0.870,1.018)	(0.885,1.031)	(0.892,1.022)	(0.926,0.993)
BMI (β-Coeff.)	0.097***	0.152***	0.085***	0.062***	0.094***
	(0.074,0.119)	(0.118,0.186)	(0.036,0.135)	(0.029,0.095)	(0.078,0.109)
Stunted (z-hfa<-2; OR)	0.7794**	0.7195**	0.6983**	0.6770**	0.7336**
	(0.744,0.811)	(0.679,0.756)	(0.645,0.756)	(0.634,0.726)	(0.71,0.756)
Underweight (z-bmi<-2; OR)	0.8962**	0.9147**	0.9423	0.9329**	0.9140**
	(0.869,0.923)	(0.876,0.942)	(0.735,1.201)	(0.884,0.97)	(0.897,0.932)
z-hfa (β-Coeff.)	0.127***	0.121***	0.126***	0.127***	0.127***
	(0.117,0.137)	(0.110,0.133)	(0.116,0.136)	(0.119,0.136)	(0.122,0.132)
z-bmi (β-Coeff.)	0.057***	0.076***	0.028***	0.030***	0.050***
	(0.046,0.067)	(0.060,0.091)	(0.012,0.044)	(0.016,0.045)	(0.043,0.056)
Association between conditional relative weight gain and education human capital accumulation					
Secondary education (OR)	1.115***	1.024*	1.059***	1.045**	1.05***
	(1.071,1.161)	(0.997,1.051)	(1.021,1.097)	(1.001,1.092)	(1.033,1.067)
Years of schooling (β-Coeff.)	0.077***	0.006	0.029**	0.018*	0.035***
	(0.054,0.100)	(-0.029,0.040)	(0.001,0.057)	(-0.000,0.036)	(0.021,0.049)
PPVT score (β-Coeff.)	0.749***	0.419**	0.204**	0.469***	0.392***
	(0.321,1.176)	(0.024,0.813)	(0.013,0.394)	(0.197,0.741)	(0.223,0.561)
Math score (β-Coeff.)	0.097***	0.076**	0.043	0.143***	0.082***
	(0.050,0.143)	(0.017,0.135)	(-0.024,0.109)	(0.063,0.223)	(0.051,0.113)
Association between conditional relative weight gain and health human capital accumulation					
Height (β-Coeff.)	1.411***	0.901***	0.733***	0.851***	1.022***
	(1.389,1.433)	(0.855,0.947)	(0.676,0.789)	(0.800,0.902)	(0.999,1.045)
BMI (β-Coeff.)	0.098***	0.200***	0.210***	0.206***	0.169***
	(0.077,0.118)	(0.177,0.223)	(0.175,0.245)	(0.181,0.230)	(0.157,0.181)
Stunted (z-hfa<-2; OR)	0.1699**	0.6383**	0.6384**	0.5950**	0.5833**
	(0.106,0.264)	(0.598,0.677)	(0.582,0.698)	(0.548,0.651)	(0.557,0.607)
Underweight (z-bmi<-2; OR)	0.8786**	0.8698**	0.8442	0.8113**	0.8694**
	(0.849,0.905)	(0.834,0.896)	(0.654,1.082)	(0.768,0.852)	(0.85,0.887)
z-hfa (β-Coeff.)	0.188***	0.119***	0.096***	0.112***	0.136***
	(0.185,0.191)	(0.113,0.126)	(0.088,0.103)	(0.105,0.119)	(0.132,0.139)
z-bmi (β-Coeff.)	0.060***	0.095***	0.065***	0.090***	0.077***
	(0.050,0.071)	(0.085,0.106)	(0.054,0.076)	(0.079,0.101)	(0.072,0.083)

*Note: * p≤0.10, ** p≤0.05, *** p≤0.01; 95% confidence interval (CI) in parenthesis.*

Table 3: Quantile regression coefficient of conditional linear growth and conditional relative weight gain on health and education human capital measures, adjusted for the background covariates, pooled, 2009

Association between conditional linear growth and education human capital accumulation					
	Quantile10	*Quantile25*	*Median*	*Quantile75*	*Quantile90*
Years of schooling (β-Coeff.)	0.050***	0.044***	0.041***	0.032***	0.021*
	(0.032,0.068)	(0.031,0.057)	(0.030,0.051)	(0.024,0.040)	(-0.001,0.043)
PPVT score (β-Coeff.)	0.514***	0.424***	0.392***	0.249***	0.164**
	(0.226,0.803)	(0.188,0.661)	(0.189,0.595)	(0.086,0.411)	(0.019,0.309)
Math score (β-Coeff.)	0.048***	0.073***	0.067***	0.081***	0.106***
	(0.015,0.080)	(0.037,0.109)	(0.030,0.104)	(0.030,0.131)	(0.038,0.174)
Association between conditional linear growth and health human capital accumulation					
Height (β-Coeff.)	1.030***	1.061***	1.069***	0.996***	0.888***
	(0.979,1.080)	(1.017,1.105)	(1.025,1.114)	(0.950,1.043)	(0.822,0.954)
BMI (β-Coeff.)	0.071***	0.077***	0.083***	0.089***	0.109***
	(0.053,0.090)	(0.061,0.093)	(0.066,0.099)	(0.067,0.111)	(0.078,0.140)
z-hfa (β-Coeff.)	0.137***	0.139***	0.142***	0.134***	0.119***
	(0.130,0.144)	(0.133,0.146)	(0.136,0.148)	(0.127,0.140)	(0.110,0.128)
z-bmi (β-Coeff.)	0.049***	0.048***	0.050***	0.048***	0.049***
	(0.039,0.059)	(0.039,0.056)	(0.041,0.059)	(0.038,0.059)	(0.035,0.062)
Association between conditional relative weight gain and education human capital accumulation					
Years of schooling (β-Coeff.)	0.043***	0.033***	0.032***	0.023***	0.016*
	(0.029,0.057)	(0.023,0.044)	(0.023,0.041)	(0.015,0.030)	(-0.002,0.034)
PPVT score (β-Coeff.)	0.373***	0.330***	0.307***	0.133**	0.138**
	(0.157,0.590)	(0.139,0.521)	(0.137,0.478)	(0.005,0.261)	(0.006,0.270)
Math score (β-Coeff.)	0.053***	0.072***	0.075***	0.080***	0.092***
	(0.014,0.091)	(0.029,0.114)	(0.030,0.120)	(0.031,0.129)	(0.027,0.158)
Association between conditional relative weight gain and health human capital accumulation					
Height (β-Coeff.)	1.095***	1.151***	1.160***	1.193***	1.216***
	(1.047,1.143)	(1.114,1.188)	(1.123,1.198)	(1.158,1.228)	(1.179,1.253)
BMI (β-Coeff.)	0.140***	0.147***	0.150***	0.161***	0.188***
	(0.125,0.155)	(0.132,0.162)	(0.133,0.166)	(0.141,0.181)	(0.162,0.214)
z-hfa (β-Coeff.)	0.147***	0.154***	0.156***	0.160***	0.162***
	(0.140,0.154)	(0.148,0.161)	(0.150,0.163)	(0.154,0.167)	(0.154,0.169)
z-bmi (β-Coeff.)	0.082***	0.080***	0.079***	0.076***	0.073***
	(0.074,0.090)	(0.072,0.088)	(0.071,0.086)	(0.067,0.084)	(0.063,0.083)

*Note: * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$; 95% confidence interval (CI) in parenthesis.*

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