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Socio-Economic Status and Z-Score Standardized Height-for-Age of U.S.-Born Children (Ages 2–6)

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Abstract

This study explores socio-economic gradients in height (stature-for-age) among a nationally representative sample of 2–6 year old children in the United States. We use NHANES III (1988–1994) Youth data linked with a special Natality Data supplement which contains information from birth certificates among sampled NHANES III Youth who are less than 7 years of age. Our results indicate significant socioeconomic gradients for both maternal education and family income, net of controls for confounders, including: birth weight, gestational age, family size, and parental heights. These results are in stark contrast to those from other developed countries that seem to indicate diminished or eliminated socioeconomic disparities, net of known confounders. In the United States, it appears that socio-economic gradients have an effect on birth outcomes, and continue to have an additional direct and independent effect on height, even in early childhood.

1. Introduction

Physical growth, and height in particular, has been identified as *a mirror of society* as it has been noted that the largest disparities in height exist among the most unequal societies in general and developing countries in particular (Komlos, 2010; Tanner, 1986). Countries with a high level of socioeconomic inequality and a lack of social safety nets are known to lag well behind countries with less inequality and a more equitable distribution of resources (Komlos and Lauderdale, 2007; Komlos and Baur, 2004). Height is a particularly important measure among children as it captures cumulative nutritional status and is an excellent marker of their general health status (de Onis et al., 2007). In addition to being a robust marker of current health status, childhood height has been associated with a host of adult health outcomes and socio-economic markers¹ (Rashad, 2008; Carba et al., 2009; Rona et al., 2003).

However, socio-economic disparities in child height have greatly diminished in most developed countries; a recent review of these studies indicates that “if adjustment is made for confounding variables, especially the child’s birth weight, parental heights and number of children in the family, socioeconomic differences in height are negligible in Britain and

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¹Also see Batty et al. (2009) for an overview of the relationship between adult height and health outcomes with a focus on the role of socio-economic status.

other Northern European countries [the Netherlands]” (Rona et al. 2003, p. 143–144). Given the general dearth of childhood data sets that link health outcomes to birth certificate data in the United States (see c.f., ECLS-B and ECLS-K), this type of analysis is rarely possible. As such, it is our intention to test for the presence of socio-economic disparities in childhood height among a nationally representative sample of children aged 2–6 years in the United States. The presence of such disparities will be a clear indicator that socio-economic inequalities continue to manifest themselves in the form of height disparities that will have long term implications for future health and social outcomes.

2. Methods and Data

In order to test our hypothesis, we use NHANES III Youth data linked with birth certificate data from the NHANES Natality supplement file (National Center for Health Statistics, 2003); these data are also linked with maternal data from the NHANES adult file and contain information about the child’s mother and — to a limited extent — father. This natality linkage of birth certificate data to NHANES Youth data by NCHS represents the only linkage to date. Our analyses originate from the approximately 7,779 youths in the data set who are linked to a natality file; these linkages were only made for children under seven years of age and do not represent the full NHANES III Youth sample. We further restrict our analyses to children ages 2–6 and are left with an analytical sample size of approximately 4,401 children. As such, our analytical data set is a nationally representative sample of U.S.-born children aged 2–6 at the time of the NHANES III survey (1988–1994), and backward linkages are made to birth certificate data. Approximately 11.5% of children aged 2–6 years were not linkable to birth certificate data and these children are both slightly more socio-economically disadvantaged and more likely to be Mexican-American than those included in the analytical sample.

Our sole dependent variable is a standardized (z-score) measure of height-for-age (HAZ) which is normalized for age and gender according to CDC standards (CDC, 2000). Height was measured by a trained technician to ensure accuracy and HAZ is extracted from the examination portion of NHANES III. Although HAZ is age/gender normalized based on known parameters rather than our sample, we further adjust for both the gender and age of the child in our analyses; given the adjustment, age and gender should largely be orthogonal to the rest of the variables in the model given the z-score normalization.

Again, our key dependent variable is the standardized HAZ measure and we include two key predictor variables as markers of the socio-economic status of a family: mother’s education level (years) and a measure of income-to-poverty-level (natural log). We also include a set of covariates in our linear regression models which include the following: birth-weight of the child (scaled to thousands of grams), sex of the child (male vs; female), mother’s marital status (married vs. unmarried), household size (count), family size (count), place of residence (urban vs. rural), language of interview (Spanish vs. English), mother’s race/ethnicity (non-Hispanic White, non-Hispanic Black, Mexican-American, Other Race), mother’s height (inches), and father’s height (inches). Summary statistics are presented in Table 1.

Missing data on the independent variables are replaced with the sample mean and a dummy variable is included to indicate that the sample-mean replaced observations are missing; using a list-wise deletion approach yielded very similar results with no changes in hypothesis testing results and only nominal changes in coefficient size. For the sake of brevity, we do not report the coefficients for dummies that represent missing data. In addition, given the complex sampling design of the NHANES III-Youth data set, we adjust for any design effects inherent in the data by using the total interviewed sample final weight

(stpfqx6) as well as the total NHANES III pseudo-PSU (sdpps6) and pseudo-stratum (sdpstra6) to adjust our standard errors appropriately.

3. Results

We specify a series of OLS regression models to test our key hypothesis of the presence of socio-economic disparities in child height. Model 1 (see table 2) indicates that not only are there socioeconomic disparities, but these disparities exist for both the income-to-poverty ratio as well as for maternal education. Interaction models (not shown here) indicate that these effects are, in fact, independent of each other. Most importantly, these effects are statistically significant, and are in the expected direction. For example, each additional year of education (range 0–17 years) is associated with an increase in HAZ by .024 standard deviations — not a particularly large effect, but significant nonetheless. To illustrate in inches, a child of a mother with a college degree would be, on average, .40 inches taller than a child whose mother had only a high school degree. For each percentage increase in income-to-poverty ratio (raw range: 0–7.4), HAZ is predicted to increase by .08 standard deviations. For example, a child whose family lived at 150% of the poverty line would be, on average, 2.24 inches taller than a child whose family lived at the poverty line. In short, there are both independent and significant effects for our two socio-economic variables — education and income. Although not of direct relevance to our hypotheses, it is also worth noting that Black children have slightly taller predicted heights than White children consistent with Komlos and Breitfelder's (2008) finding of a faster tempo of growth among Black children. Further, Spanish-speaking mothers also have children with taller predicted heights. This latter effect is often attributed to the healthy migrant effect which is also manifested in advantaged birth weights for Mexican-American infants (Markides and Coreil 1986).

In Model 2, we specify an interaction between birth weight and gestation length and this product term is statistically and substantively non-significant and has only a marginal effect on our key predictors so we remove this interaction from all other models, due to the need to specify interactions between socio-economic status and both birth weight and gestation in other models. We also specify a series of interaction models (models 3–6 in Table 2) to see if the socio-economic disparities vary by either birth weight or gestational age. Models 3–4 test for a differential poverty gradient by both birth weight and gestational age; however, none of the interaction terms are significant and the estimated regression slopes are negligible. Models 5–6 test for a differential educational gradient effect by both birth weight and gestational age, but once again, these effects are not significant.

We estimated models separately by mother's race and ethnicity (Table 3). There are significant poverty gradients for both Whites and Blacks (.094 and .052, respectively), as well as an educational gradient, similar in size to the pooled model, among Whites. Among Mexican-American children, however, socioeconomic gradients are small and do not attain statistical significance; this pattern is consistent with other literature that finds weak socioeconomic gradients in health among Hispanics (Goldman et al., 2006). Similar to the pooled model, the birth weight and gestation interactions remain nonsignificant when separated by race as do the other interactions tested (not shown).

4. Discussion and Conclusions

Our results suggest significant socio-economic gradients in child height-for-age among 2–6 year olds who were born in the United States. These results hold for both education and income, which appear to exert independent effects on child height. These gradients also persist when controlled for typical confounding variables that often account for these

relationships in developed European countries. We also find that socio-economic gradients are strongest among Whites and Blacks and non-existent among Mexican-American children. It is also interesting to note the lack of interaction between socio-economic measures and age (not reported), given that most linear growth retardation occurs before the age of two (Ricci and Becker, 1996). In short, the income and education effects on height are persistent and consistent during early-childhood.

Given our unique findings, it is necessary to present some of our methodological shortcomings in greater detail. First, due to missing data issues for paternal measures, we use maternal education although previous studies have shown paternal education to be a stronger predictor of birth outcomes (Finch, 2003a); as such, our results may be biased downward. Secondly, income-to-poverty ratios are missing for approximately 15% of our linked sample. Education levels for those missing income data are a full year lower than those that are not missing. As such, our income effects may be biased in an unknown direction. Finally, while maternal height is missing for only 3% of the sample, paternal heights are missing for more than 8% of the sample. This is not an extraordinarily large pattern of missing data, but may have an effect on our confounding controls, particularly if the missing heights are biased in one extreme direction or another. It is impossible to tell if this is the case, but comparisons with maternal height (given a moderate correlation of .39 between maternal and paternal height) suggest that these missing heights may be fairly randomly distributed. Finally, 11.5% of the 2–6 years of age sample was not linkable to birth certificates and as such, our analytical sample represents a slightly more socio-economically advantaged population as well as slightly lower in Mexican-American representation.

To conclude, it has already been established that there are clear socio-economic disparities in birth outcomes in the United States (Conley and Bennett, 2000; Finch, 2003a; 2003b). Not all infants begin life with an equal chance of healthy and prosperous adulthoods; inequality makes a measurable and indelible mark on the life-chances of children in the United States. However, our study shows that birth weight is not the only pathway for the transmission of inequality. Our data indicate strong and significant socioeconomic gradients in child height, net of the most widely known confounders. Thus, while these gradients have been in decline in most developed nations, they are strong and clear in the United States. Finally, these effects do not diminish with age, but remain consistent throughout early childhood. Future studies should further address whether the effects identified here have been persistent over time, or are part of a downward trend. This may prove difficult given extant data systems in the United States, as the NHANES III Natality data set appears to be exceptional, rather than the norm for data collection efforts. Further, future studies should account for reverse causation of child health on parental socio-economic status² by using longitudinal/panel data sets that can control for unobserved heterogeneity. Although we have made an initial attempt at doing so by controlling for paternal height, repeated measures designs could be utilized in other data sets as a check on the robustness of these results.

In short, our results show persistent socio-economic gradients in height among U.S. children. Despite the wealth of the country as a whole, socio-economic disparities in the U.S. remain pronounced and the U.S. is now one of a handful of developed countries to exhibit these gradients after controlling for conditions at birth. That is, socio-economic disparities exist for birth outcomes and are further perpetuated in early childhood.

²A child's health problems could, for example, drain parental economic resources as well as limit parents' hours at work.

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Table 1

Descriptive Statistics for Model Variables.

Variable	Mean/ %	Min	Max
Height-for-Agse (HAZ)	.25 (.98)	−5.0	3.0
Child Birth Weight (1,000 g)	3305.85 (579.09)	122	4750
Gestation (wks)	39.18 (2.83)	26	47
Sex of Child (Male)	50.17	0	1
Female	49.83	0	1
Age of Child (Yrs)	3.66 (1.33)	2	6
Mother's Education (yrs)	11.64 (2.85)	1	17
Mother's Marital Status (Married)	74.92	0	1
Unmarried	9.04	0	1
Missing	16.04	0	1
Language of Interview (English)	82.05	0	1
Spanish	12.32	0	1
Missing	5.63	0	1
Mother's Ethnicity (Non-Hispanic White)	31.14	0	1
Non-Hispanic Black	32.51	0	1
Mexican-American	31.79	0	1
Other	4.55	0	1
Mother's Height (inches)	63.98 (2.83)	48	79
Dad's Height (inches)	69.17 (3.52)	51	83
Income-Poverty Ratio (ln)	.21 (.90)	−3.91	1.99
Household Size (count)	4.78 (1.78)	2	10
Family Size (count)	4.72 (1.75)	2	10
Place of Residence (Rural)	48.40	0	1
Urban	51.60	0	1

Standard Deviations in Parentheses.

Table 2

OLS Regression Results for Height-for-Age: Main and Interaction Effects.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Mother's Education (ME)	.024**	.025**	.024	.024**	.028	.178 [†]
Child Birth Weight (CBW)	.614**	1.059**	.629**	.616**	.629**	.617**
Gestation	-.035**	-.001	-.035**	-.033**	-.035**	.012
Female Child	-.150**	-.150**	-.150**	-.151**	-.150**	-.151**
Age of Child	.026	.026	.026	.026	.026	.025
Mother Unmarried	.073	.074	.074	.075	.073	.074
Interview in Spanish	.471**	.471**	.471**	.469**	.470**	.467**
Non-Hispanic Black ^a	.481**	.480**	.483**	.482**	.481**	.481**
Mexican-American ^a	-.035	-.034	-.039	-.036	-.035	-.037
Other Race/Ethnicity ^a	.091	.090	.108	.090	.090	.085
Mother's Height	.022**	.022**	.022**	.022**	.022**	.022**
Dad's Height	.010**	.011**	.010**	.010**	.010**	.010**
Income-Poverty Ratio (I-P-R)	.075*	.078*	.179	.358	.075*	.076*
Household Size	-.091*	-.090*	-.090*	-.092*	-.091*	-.091*
Family Size	.051	.051	.050	.052	.051	.051
Urban Residence	.106*	.099 [†]	.108*	.106*	.106*	.105*
CBW * Gestation		-.0001				
I-P-R * CBW			-.031			
I-P-R * Gestation				-.007		
ME * CBW					-.0001	
ME * Gestation						-.004
Constant	-2.849	-4.195	-2.902	-2.954	-2.900	-4.712
R ²	.204	.204	.204	.204	.204	.204
Sample Size	4,401	4,401	4,401	4,401	4,401	4,401

Note:

**
p<.01;

*
p<.05;

†
p<.10.

^a Mother's Race/Ethnicity

Table 3

OLS Regression Results for Height-for-Age: By Race and Ethnicity.

Variable	Whites	Blacks	Mexican- Americans
Mother's Education (ME)	.021 *	.011	.008
Child Birth Weight (CBW)	.497 **	.411 **	.534 **
Gestation	-.033	-.037	-.003
Female Child	-.178 **	-.134 **	-.048
Age of Child	.015	.026	-.031
Mother Unmarried	.154	.084	.005
Interview in Spanish	--	--	.149 **
Mother's Height	.031 **	.017 **	.005 †
Dad's Height	.012 **	.007 **	.005 †
Income-Poverty Ratio (I-P-R)	.093 *	.052 †	.041
Household Size	-.227s †	.037	-.091 *
Family Size	.202 †	-.074	.043
Urban Residence	.040	.029	.047
Constant	-5.824	-1.343	-2.010
R ²	.183	.122	.109
Sample Size	1,371	1,431	1,399

Note:

**
p<.01;*
p<.05;†
p<.10.