

## HEIGHT, HEALTH AND ECONOMIC DEVELOPMENT<sup>†</sup>

### Height, Health, and Cognitive Function at Older Ages

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Research across a number of disciplines has highlighted the role of early life health and circumstance in determining health and economic outcomes at older ages. Nutrition *in utero* and in infancy may set the stage for the chronic disease burden that an individual will face in middle age (David J. Barker 1998; Barker et al. 1989; Johann Eriksson et al. 2001). Childhood health may also have significant effects on economic outcomes in adulthood. Collectively, a set of childhood health measures can account for a large fraction of the explained variance in employment and social status observed among a British cohort followed from birth into adulthood (Case, Angela Fertig, and Paxson 2005).

Recent research has paid particular attention to height as a marker of a child's early environment. A baby's length in infancy and height in childhood are strongly predictive of cognitive ability (Susan A. Rose 1994; Marcus Richards et al. 2002; Case and Paxson 2006), with better nutrition and health leading both to taller children and to greater cognitive function (Richard Lynn 1989). Analysis of data from British birth cohorts finds that a one-standard-deviation increase in height is associated on average with a  $1/10$ -standard-deviation increase in scores on standardized language, math, and drawing tests, measured at a variety of ages in childhood, with or without controls for parents' heights, education, and social status (Case and Paxson 2006).

The association between height at age 3 and height in adulthood is strong (the correlation coefficient is greater than 0.7 for both men and women), so that adult height provides a marker

for the nutrition and health environment that an adult experienced in early life. Data from the United States and Britain suggest that some of the advantages bestowed by more favorable health and environmental circumstance, as measured by height, follow children into adulthood: not only are taller adults more likely to work in white collar occupations, but every inch of height is associated with a 2 to 2.5 percent increase in earnings for both men and women, on average. The height premium observed in earnings among taller adults in the British birth cohorts can be explained by greater cognitive function, measured using scores on tests taken at young ages (Case and Paxson 2006).

How lasting are these effects? In this paper, we argue that the advantages offered by a healthier early life environment—as measured by height—follow adults into old age. We use several waves of data from the Health and Retirement Study (HRS) to document the extent to which height is associated with more favorable outcomes for individuals above the age of 50. We find that taller men and women have greater cognitive function, measured on a wide variety of dimensions. They report significantly fewer difficulties with activities of daily living, on average, and significantly greater health and mental health. We present evidence on some of the mechanisms through which early life health and nutrition may affect outcomes at older ages, and discuss others that require further research.

#### I. The Health and Retirement Study

Our analysis is based on the HRS, a longitudinal study sponsored by the National Institute on Aging, which is carried out by the Institute for Social Research at the University of Michigan. Since 1992, the HRS has been following a cohort of men and women in the United States over the age of 50, in order to better understand the physical and mental health, quality of life, and life

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TABLE 1—COGNITIVE FUNCTION, HEALTH STATUS, DEPRESSION, AND HEIGHT IN THE HRS

	Dependent variable:					
	Delayed word recall [4.68]	Counting backward [0.88]	Knows the date [0.82]	ADL difficulty [0.24]	Depression [1.43]	Health status [2.72]
Height in inches	0.043 (0.004)	0.003 (0.001)	0.003 (0.001)	-0.003 (0.002)	-0.023 (0.005)	-0.011 (0.003)
<i>N</i>	67,787	53,580	46,954	73,239	73,271	73,258

*Notes:* OLS coefficients reported with standard errors in parentheses. All regressions include a complete set of five-year age category indicators, wave indicators, and race and sex indicators. All regressions are weighted using sample weights. Standard errors adjust for clustering by individual. Weighted means are provided in square brackets for each dependent variable.

circumstances of older Americans (see <http://hrsonline.isr.umich.edu> for details). Because some of the health indicators we are interested in were collected for the whole cohort only beginning in Wave 3 of the study (1996), we restrict our analysis to Waves 3 to 7, which were collected in even years between 1996 and 2004. To reduce heterogeneity, we further restrict our analysis to non-Hispanic men and women ages 50 and older for whom no proxy respondent was used.

The HRS collects a variety of measures of cognitive function, health and mental health status, and difficulties with daily life that can be used to examine the extent to which height is protective of well-being at older ages. Given our space constraints, we focus on six markers: three measures of cognitive function (word recall, counting backward, knowing the day and date), and self-reports of health status, depression, and difficulties with activities of daily living.

Delayed word recall records the number of words that the respondent can remember approximately five minutes after having heard a list of ten nouns read aloud. Counting backward is an indicator the respondent can correctly count backward by ones from 86 to 77 (asked in each wave from 3 to 6). Knowing the date and day of the week is recorded as an indicator variable. It is asked of all respondents aged 65 and above, and younger respondents not surveyed in earlier waves. Difficulties with activities of daily living is an index of the number of tasks the respondent reports having difficulty performing, from a list of dressing, bathing, eating, walking across a room, and getting in or out of bed. The depression measure is the Center for Epidemiologic Studies Depression (CESD) scale, which is the sum of six “negative” indicators (being depressed, everything being an effort, having restless sleep,

feeling lonely, feeling sad, not being able to get going) plus the absence of two “positive” indicators (being happy, enjoying life). Health status is the response to the question “how is your health at present?” where responses are coded as (excellent = 1, very good = 2, good = 3, fair = 4, poor = 5). Means of these measures of well-being for our sample are provided in square brackets in Table 1. (Additional detail on these measures is available online at <http://hrsonline.isr.umich.edu/docs/userg/dr-006.pdf>.)

The HRS asked respondents to report their heights in Waves 1 and 2. Respondents who were not surveyed in Waves 1 and 2 were asked their heights when they were first interviewed. One potential problem is that the heights of these older adults could reflect shrinkage that occurs with aging, which may be more pronounced for individuals with some health problems. However, the respondents were still relatively young (with an average age of approximately 60 years) when they reported their heights. Furthermore, self-reports of height may be less likely to reflect age-related shrinkage than measured heights.

## II. Results

Table 1 reports estimation results in which these measures of well-being are regressed on respondents’ heights, recorded in inches, controlling for age, survey wave, race and sex. (Results are qualitatively unchanged when regressions are run separately by sex, and when health status estimates are derived from an ordered probit rather than an OLS regression.) We find that, on average, taller respondents in the HRS outperform shorter respondents on cognitive tests. Moving an individual from the twenty-fifth to the seventy-fifth percentile of height in the HRS (a change from

TABLE 2—DETERMINANTS OF HEIGHT, EDUCATION, AND OCCUPATIONAL CHOICE

	Dependent variable:			
	Height in inches	Completed education	White collar occupation	White collar occupation
Height in inches	—	0.106 (0.007)	0.010 (0.001)	0.003 (0.001)
Completed education	—	—	—	0.067 (0.001)
Childhood SES reported as “well off”	0.195 (0.073)	1.417 (0.072)	0.105 (0.013)	0.010 (0.012)
Childhood health status reported as “excellent” or “very good”	0.245 (0.045)	0.759 (0.045)	0.091 (0.008)	0.040 (0.007)
<i>N</i>	20,202	20,137	20,202	20,137

*Notes:* OLS coefficients reported with standard errors in parentheses. All regressions include a complete set of five-year age category indicators, wave indicators, and race and sex indicators. All regressions are weighted using sample weights.

68 to 72 inches for men, and 62 to 66 inches for women) is associated with a 1.2 percentage point increase in the probability of counting backward from 86 correctly, and of knowing the day and date. Height is also associated with better physical and mental health outcomes. Controlling for age, race, sex, and survey wave, we find that taller HRS respondents report significantly fewer difficulties with activities of daily living, less depression, and better general health status (noting that a lower number for the latter is a report of better health). Moreover, the association between these measures of wellbeing and height hold throughout the range of height for both men and women. (See <http://www.princeton.edu/~rpds/downloads/casepaxsoncogfunctionadditional.pdf> for non-parametric regression results that demonstrate this.)

There are many reasons why height may be associated with better cognitive function, health, mental health, and activities of daily living at older ages. Height is a marker of early childhood health and nutrition, both of which affect cognitive development. Together, childhood environment and cognitive development affect educational attainment and school achievement and, later, occupational choice. All of these may in turn affect health and cognitive function in old age. Education is thought to be protective of health status, in part through the role that education (or the level of abstract reasoning that accompanies education) plays in supporting adherence to medical protocols (Dana P. Goldman and James P. Smith 2003). In addition, individuals who select into manual occupations have more rapid deterioration in their self-

assessed health than do those in white collar jobs (Case and Angus Deaton 2003). Research has also documented decline in cognitive function due to past exposure to neurotoxicants in the workplace, for which white collar workers are at lower risk (Brian S. Schwartz et al. 2000). Childhood health and nutrition may also influence cognitive function at older ages through effects on adult health. Poor health and nutrition in childhood may lead to problems such as diabetes, hypertension, and vascular disease, which are associated with poorer cognitive function among the elderly (David Knopman et al. 2001; Kristine Yaffe et al. 2004; Eric J. Brunner 2005).

The first column of Table 2 presents childhood correlates of height. HRS respondents who report having been raised in households that were “well off” financially are, on average, 0.20 inches taller than those who report less comfortable childhoods. Respondents who report having been in excellent or very good health during childhood are on average 0.25 inches taller than other cohort members. It is not possible to know whether the absence of chronic health conditions in childhood led cohort members to be taller, or whether both height and health were driven by the same underlying environmental conditions, or perhaps both. However, these results are consistent with height providing a marker of a healthier and financially more comfortable early life environment. The effects of childhood health and socioeconomic status (SES) may attach to height in regressions of the determinants of adult outcomes, if information on childhood circumstance is not available.

Table 2 also presents results on the determinants of completed education (column 2) and white collar employment (columns 3 and 4). We find that having been raised in a higher SES household and having been in excellent or very good health in childhood are highly significantly correlated with educational attainment and occupational choice. Being raised in a high SES household is associated with an additional 1.4 years of schooling, and an increase in the probability of white collar work of 11 percentage points. Excellent health in childhood is associated with 0.8 additional years of schooling, and an increased probability of white collar work of 9 percentage points. Even with these controls, height remains a significant determinant of education and occupation among HRS respondents.

In earlier work, we found height was strongly associated with cognitive ability in childhood. If, as seems likely, cognitive function is not fully captured by our measures of childhood health and SES, height may be standing in for early-life cognitive function in these regressions. To explore this idea, we add completed education to the list of determinants of white collar work. Completed education will capture both its own effect on white collar employment, and that part of cognitive ability that projects onto education. Education is a very strong predictor of white collar employment, and its inclusion in the set of controls reduces the association between height and white collar work by two-thirds.

We can use these data to test whether these life course events—health and economic status in childhood, educational attainment, and white collar employment in adulthood—appear to be responsible for the significant and uniformly positive association we find between height and well-being at older ages. Table 3 presents results of regressions, similar to those presented in Table 1, but which now include measures of childhood health and circumstance, educational attainment, and employment in a white collar job.

We find that childhood health, completed education, and an indicator that employment was in a white collar occupation are all significantly correlated with cognitive function at older ages, and also predict better health and mental health, and fewer difficulties with activities of daily living. Moreover, their inclusion renders the coefficient on height insignificantly different from zero for five of our six measures of well-being.

The inclusion of education as a control is largely responsible for the diminished role of height in these regressions. For two of our cognitive function measures, knowing the date and counting backward, the height coefficients become insignificant once a control for education is included. In contrast, although highly significant, a control for white collar work does not render the height coefficient insignificant (although its inclusion does reduce the size of the height coefficients by approximately 15 percent). For delayed word recall, the inclusion of education reduces the height coefficient by half (from 0.043 to 0.022), although the height coefficient is still significant. In addition, the inclusion of education renders insignificant the associations between height and self-assessed health status, and between height and reports of difficulties with activities of daily living. Similarly, childhood SES, which is a significant correlate of all six well-being measures in the absence of a control for education, becomes insignificant for five of six measures in the presence of education.

In the absence of data from cradle to grave on cognition, it is not possible to know why higher educational attainment is associated with better cognitive outcomes at older ages. One possibility is that education has a causal role in helping individuals maintain cognitive ability over time. Another is that higher educational attainment reflects better early-life cognitive ability, which persists into old age. Yet another explanation is that educational attainment is a better marker for early-life economic advantage than are respondents' own reports of childhood SES. Future research that uses data on cohorts followed from early to late life may shed light on which of these mechanisms are at work.

### III. Conclusions

The analyses shown above indicate that early life experiences—as summarized by height—have important consequences for well-being at older ages. Height is associated with better mental and physical health and cognitive function in late life. Research on the determinants of both height and cognitive ability suggests that health and nutrition in early childhood may be a key factor in the association between height and cognitive ability. If this is correct, then the results shown above have implications for the value of investments in health and nutrition in

TABLE 3—THE ROLE OF EARLY- AND MID-LIFE CIRCUMSTANCES ON OUTCOMES IN THE HRS

	Dependent variable:					
	Delayed word recall	Counting backward	Knows the date	ADL difficulty	Depression	Health status
Height in inches	0.022 (0.004)	0.001 (0.001)	0.001 (0.001)	0.000 (0.002)	-0.008 (0.004)	0.001 (0.003)
Childhood SES "well off"	-0.017 (0.048)	-0.009 (0.007)	-0.011 (0.008)	0.060 (0.024)	0.072 (0.047)	-0.004 (0.033)
Childhood health excellent/very good	0.142 (0.027)	0.017 (0.005)	0.025 (0.005)	-0.124 (0.013)	-0.457 (0.030)	-0.393 (0.017)
Completed education	0.161 (0.004)	0.018 (0.001)	0.013 (0.001)	-0.025 (0.002)	-0.112 (0.005)	-0.082 (0.003)
White collar occupation	0.303 (0.026)	0.016 (0.004)	0.027 (0.005)	-0.064 (0.010)	-0.205 (0.027)	-0.177 (0.017)
N	67,097	52,948	46,334	72,512	72,535	72,524

Notes: OLS coefficients reported with standard errors in parentheses. All regressions include a complete set of five-year age category indicators, wave indicators, and race and sex indicators. All regressions are weighted using sample weights. Standard errors adjust for clustering by individual.

early childhood. Previous research has focused on the returns to early investments in the labor market. However, our findings indicate that these benefits may extend into the retirement years, in the form of better physical and mental functioning.

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