Early educational experiences and trajectories of cognitive functioning among mid-life and older U.S. adults

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Abstract

Educational attainment is associated with better cognitive functioning among older adults, but significant variation in educational experiences exists even at equivalent levels of educational attainment. We use data from the 2015 Health and Retirement Study Life History Mail Survey (LHMS) to examine if educational content, school context, and academic ability relate to trajectories of cognitive functioning, independent of educational attainment among mid-life and older US adults. We restrict our sample to age-eligible LHMS respondents who provided data on cognitive functioning at least once between 1998 and 2014, and attended primary school or higher (n=6,056 respondents providing 38,452 person-period observations). Estimates from linear mixed models revealed that educational content, school context, and academic ability were significantly related to cognitive functioning at age 65, but not to the rate of cognitive decline, independent of educational attainment. Further, educational experiences explained about 22% of the educational gradient in cognitive functioning at age 65.

Introduction

Educational attainment is one of the strongest predictors of cognitive functioning among older adults.[1-5] More educated adults report higher baseline cognitive functioning than less educated adults though it is less clear if they also experience a slower rate of cognitive decline.[1, 5] For example, using a nationally representative sample of adults 75 years and older, Alley and colleagues (2007) found a positive, linear relationship between education and baseline performance on mental status, working memory, and verbal memory. More education was also associated with a slower decline in mental status, but a slightly faster decline in verbal memory. A longitudinal study of Canadians 55 and older residing in Victoria, British Columbia similarly found a strong, positive relationship between education and cognitive functioning, but no relationship to cognitive decline across any of the domains in cognitive functioning.[5]

Most studies examining the role of education in cognitive functioning and decline have focused solely on attainment; however, there are aspects of early life education – including school context, content, and ability – that prior research demonstrates are important for physical and mental health[6-9] as well as cognitive functioning.[10-14] For example, a number of studies have found that aspects of early life educational quality, including pupil-teacher ratio and school-term length, are related to cognitive performance among mid-life and older adults.[12, 13] Others have shown that school context matters; among a community sample of Baltimore residents 50 years of age and older, researchers found that attending a racially-mixed school was associated with better cognitive performance than attending a racially-segregated school, though school segregation had no relationship to decline.[10] In addition, Sisco and colleagues (2013) found a relationship between educational quality and cognition among older adults residing in northern Manhattan. In their study, the researchers created a composite measure of educational quality using both self-reported indicators of school context and administrative records of school term length, school days attended, and classroom size. Among older Black Manhattan residents, greater educational quality was associated with higher levels of cognitive functioning and a slower rate of decline. Taken together, these studies suggest there are important aspects of education beyond attainment that, though typically overlooked, could increase our understanding of why education protects against poor cognitive functioning and, by extension, dementia. To date, however, our knowledge of the relationship between early educational experiences and cognitive functioning is based on data from only a handful of community-based samples, which may not reflect the early educational experiences of U.S. older adults.

Our study addresses this key limitation by using recently released retrospective data on childhood school context, content, and academic ability among a nationally representative sample of mid-life and

older adults. Further, given that school content and context have changed over time, we examine if these aspects of education differentially relate to cognitive functioning across birth cohorts. Our study is important because dementia prevalence appears to be declining in the United States, possibly due to increasing levels of educational attainment.[15] And yet, significant variation in early educational experiences exists across cohorts. If these early educational experiences are independently associated with cognition and dementia risk, this might suggest that policy interventions that improve educational quality may result in additional reductions in dementia risk.

Our study addresses two questions. First, does school content, school context, and academic ability impact level and decline of cognitive functioning independent of educational attainment among a nationally representative sample of mid-life and older U.S. adults? Second, does the relationships between school content, context, and academic ability vary by cohort?

Methods

Data and Sample

We use data from the Health and Retirement Study (HRS), a nationally representative, longitudinal study of U.S. adults over age 50. Since 1992, the HRS has conducted core interviews with age eligible respondents and their spouses approximately every two years. In 2015, HRS collected information about the respondents' residential and schooling history and other childhood events through a Life History Mail Survey (LHMS). The LHMS was sent to 11,256 HRS respondents and their spouses from the 2014 core interview, who were not selected for the 2015 Consumption and Activities Mail Survey (CAMS), and who completed their most recent core interview in English. Just over half of contacted respondents (n=6,481; 58%) returned their completed questionnaires.

We restrict our sample to age eligible HRS respondents who completed the LHMS (n=6,096), provided data on cognitive functioning at least once between 1998 and 2014 (n=6,062), and attended at least primary school. This resulted in an analytic sample of 6,056 respondents providing 38,452 person-period observations (mean observations = 6.3). Item non-response on the independent variables and covariates ranged from <1% to 12%. To address issues of item non-response, we used multiple imputation methods (details provided below).

Due to the eligibility requirements for the LHMS and the timing of administration, the LHMS sample is younger, less cognitively impaired, and more highly educated than the comparable HRS sample (see supplemental table S1).

Measures

Dependent variable. HRS uses a modified version of the Telephone Instrument for Cognitive Status or TICS to assess *cognitive function* both in face-to-face interviews and by telephone. We constructed a total cognitive function score by summing scores across the following tests of memory and mental status: (a) an immediate word recall test in which respondents are read a list of 10 common nouns and are immediately asked to repeat as many words from the list as they can recall (10 points); (b) a delayed recall test, occurring approximately 5 minutes later, of the same 10 words (10 points); (c) a serial 7's subtraction test requiring respondents to subtract 7 from 100 five times (5 points); (d) a backwards counting test requiring respondents to count backwards as quickly as possible for 10 continuous numbers from the number 20 (2 points if correct on first attempt, 1 point if correct on second attempt); (e) naming the day of the week and the date (4 points); (f) naming the president and vice-president (2 points); and (g) identifying two objects, 'scissors' and 'cactus' (2 points). We assigned full points on the naming and object identification tests tor respondents under age 65 who were not asked these questions. These tests do not differentiate impairment in younger populations because older adults under age 65 typically provide correct answers to all questions. The total cognitive function score was normally distributed and values ranged from 0 to 35.

Educational attainment. We used information from degrees received and years of education to classify respondents as having 1) less than a high school diploma, 2) GED or high school diploma, 3) some college, or 4) a bachelor's degree or higher. Other specifications of educational attainment yielded similar results as those we present.

Educational experiences. Measures about academic ability, school context, and educational content come from the LHMS. We classified respondents as having a *learning problem* if they affirmed that during elementary school a professional told them or their parents that they had a problem with learning any of four subject matters (i.e., reading, writing, mathematics, speaking/language) or had diagnosed them with Attention Deficit Hyperactivity Disorder, dyslexia, or another learning disorder. Respondents self-assessed their *reading and math ability* at age 10 in comparison to other children in their class (1=much better, 2=better, 3=average, 4=worse, 5=much worse). We include these indicators as continuous measures. For each elementary school attended, respondents reported if 1) their *average class size* was more than 30 students or 30 or fewer students and 2) most children at their school were White, Black, Hispanic, or another racial group. *Classroom size* was classified as small (as compared to large) if respondents ever reported being enrolled in an elementary class that had 30 or fewer students. We classified respondents as ever attended a *majority non-White elementary school* if most students in their school were Black, Hispanic, or another racial group. Respondents reported on their *high school*

curriculum, which we classified as 1) did not attend high school, 2) vocational or general education, and 3) college preparatory. We also include an indicator of respondents' involvement in *language or creative arts*, which we classified as yes if they studied a foreign language, played a musical instrument, took singing lessons/sang in a choir, learned ballet or dance, or learned to paint or draw. Finally, in the core HRS interview, respondents reported whether they lived in a *rural area* most of the time they were in school.

Covariates. To account for childhood factors that may confound the relationship between educational experiences, attainment, and cognitive functioning, we include *parent's education* measured as the highest number of years of school completed by either parent, the *number of books* in the childhood home (1=none or few, 2=one shelf, 3=one bookcase, 4=two bookcases, 5=more than two bookcases), and *self-reported childhood health* (1=excellent, 2=very good, 3=good, 4=fair, 5=poor). Other measures of childhood socio-economic status (SES), including self-reported SES, father's unemployment status, and residential moves due to financial difficulties, did not alter our overall findings when included in the model, but did increase multicollinearity. We therefore did not include these indicators in our final models. Demographic covariates included self-reported race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other race/ethnicity), birth cohort ((AHEAD/CODA (b. ≤ 1930), HRS/War Babies (b. 1931 – 1947), or Early and Mid-Boomers (b.1948 – 1959)), gender (male or female), and if the LHMS was completed by a proxy (0=completed on own, 1 = had help completing or proxy completed).

Analytic Approach

To address issues of item non-response, we imputed data using the *mi impute* command with chained equations specification in Stata v14. Imputation models included all analytic variables as well as variables that were likely to be theoretically related to item non-response. This produced 20 data sets. Analyses were replicated across the 20 datasets and combined using *mi estimate.*

We used linear mixed models to account for repeated observations of cognitive functioning and varying numbers of observations per person. Age represents time in our models, and was centered at age 65, the mean age of respondents across the period of investigation. All independent variables and covariates were interacted with age to examine their influence on the rate of change in cognitive functioning. Our linear mixed models included two random terms that were assumed to be normally distributed with mean zero, and independent of within-person error and all model covariates. Linear mixed models were estimated using *mixed* in Stata v14 software.

We estimated three models. Model 1 estimated the relationship between educational attainment and trajectories of cognitive functioning without adjustment for earlier educational experiences. Model 2

estimated the relationship between educational experiences and trajectories of cognitive functioning without adjustment for educational attainment. Model 3 estimated the relationship between educational experiences and trajectories of cognitive functioning after adjustment for educational attainment. All models include childhood and demographic covariates.

Before estimating our models, we examined mean cognitive functioning by age across birth cohorts (Figure 1) and determined that a linear specification of age fit the data best. Mean plots also revealed significant cohort differences in cognitive functioning. Overall, cognitive functioning was highest at younger ages (mean=24.8 at ages 50-54) and declined with age.

Results

Sample Characteristics

Table 1 presents sample characteristics for the full sample and by birth cohort. Most respondents were White (74.4%), over 56% were women, and more than half had completed some college or more. On average, their most educated parent completed 11 years of school, they reported one shelf to one bookcase worth of books in their childhood home (M=2.2), and they rated their childhood health as very good to excellent (M=1.7). Most respondents' elementary classes had 30 or fewer students (82.4%), but less than a quarter ever attended a predominantly non-White elementary school (22.6%). Respondents generally rated their reading and math ability as between "average" to "better than their classmates" (M=2.4 and 2.6, respectively). Only 11.4% reported a learning problem. Around two-thirds of respondents were involved in language or creative arts in high school (69.1%) or were enrolled in vocational or general education curriculum (72.2%).

Demographic differences across cohorts likely reflect a combination of selective mortality, demographic shifts, and changes in U.S. schooling. For example, compared to the AHEAD/CODA cohort, fewer respondents in the Early and Mid-Boomer cohorts were White or women. Early and Mid-Boomers were also more educated than the AHEAD/CODA cohort, more likely to have attended a majority non-White elementary school (31% vs. 9.9%) and more likely to have learned a foreign language or participated in creative arts (73% vs. 61.5%).

Linear Mixed Models

Table 2 presents estimates from linear mixed models. Model 1 shows estimates for educational attainment. At age 65, there was a clear educational gradient in cognitive functioning. Compared to respondents with a college degree or more, respondents with less than a high school diploma scored about 4 points lower on the cognitive functioning assessment, respondents with a high school diploma or GED scored almost 2 points lower, and those with some college scored 1 point lower. As respondents aged,

their cognitive functioning declined by 0.17 units per year. Educational attainment, however, was unrelated to the rate of decline in cognitive functioning.

Model 2 shows estimates for academic ability, school context, and educational content. At age 65, all of these educational experiences were significantly associated with cognitive functioning. A small class in elementary school (b=.35, SE=0.10) and involvement in language or creative arts in high school (b=0.81, SE=0.09) were positively associated with cognitive functioning at age 65. Respondents with a learning problem in elementary school scored 1.1 points lower on cognitive functioning at age 65 than those without a learning problem. Lower ratings on reading (b=-0.29, SE=0.05) and math (b=-0.53, SE=0.05) ability in elementary school were associated with lower cognitive functioning at age 65 as was being enrolled in vocational or general education curriculum in high school (b=-0.40, SE=0.09) versus a college preparatory curriculum. Finally, attending a school in a rural area was associated with lower cognitive functioning at age 65 than attending a school in a non-rural area (b=-0.46, SE=0.07). None of these educational experiences were related to rate of decline in cognitive functioning, however.

Model 3 shows estimates for educational experiences after inclusion of educational attainment. Inclusion of educational experiences explained about 22% of the educational gradient at age 65. Most of the educational experiences remained significantly associated with cognitive functioning at age 65 though slightly attenuated, with the exception of high school curriculum, which was no longer statistically significant. As in Models 1 and 2, none of the variables were related to the rate of cognitive decline.

Given selective mortality, demographic shifts, and changes in U.S. schooling across cohorts, we re-estimated Model 3 but did not interact our variables of interest with age since neither educational attainment nor educational experiences were related to the rate of cognitive decline. In Table 3, similar to the findings from the full model, there was a clear educational gradient in cognitive functioning for HRS and more recent cohorts. For the AHEAD/CODA cohort, only individuals with less than a high school degree versus college degree or higher differed in their level of cognitive functioning. Fewer of the educational experiences were significantly related to cognitive functioning among the AHEAD/CODA cohort than the HRS and more recent cohorts.

Table 1: Sample characteristics by birth cohort, Health and Retirement Study, LHMS Sample, Mean (SE) or %

	Full	AHEAD / CODA	HRS / War Babies	Boomers
	n=6,056	n=548	n=2,810	n=2,698
Demographics				
Race/ethnicity				
Non-Hispanic White	74.4%	89.6%	81.5%	63.9%
Non-Hispanic Black	17.6%	6.4%	13.7%	23.9%
Latino	5.2%	2.7%	3.0%	8.0%
Other	2.8%	1.3%	1.7%	4.2%
Female	59.2%	65.5%	59.0%	58.1%
Proxy interview, Life history module	8.2%	21.7%	9.2%	4.5%
Childhood and Family Experiences				
Parent's education	11.1 (0.04)	9.6 (0.15)	10.8 (0.07)	11.7 (0.06)
Number of books in the home [a]	2.2 (0.01)	1.9 (0.05)	2.0 (0.02)	2.5 (0.02)
Self-rated health in childhood [b]	1.7 (0.01)	1.8 (0.04)	1.7 (0.02)	1.7 (0.02)
School Experiences				
Diagnosed learning problem	11.4%	6.7%	8.7%	15.2%
Class size less than 30 students	82.4%	85.8%	82.8%	81.3%
Reading ability compared to peers [c]	2.4 (0.01)	2.3 (0.04)	2.4 (0.02)	2.4 (0.02)
Math ability compared to peers [c]	2.6 (0.01)	2.5 (0.04)	2.6 (0.02)	2.6 (0.02)
Attended majority non-White elementary school	22.6%	9.9%	17.1%	31.0%
Involved in language or creative arts	69.1%	61.5%	66.8%	73.0%
High school curriculum				
Never attended high school	2.3%	4.9%	3.1%	1.0%
Vocational or general education	72.7%	74.9%	73.6%	71.3%
College preparatory	25.0%	20.2%	23.3%	27.8%
Lived in rural area during school	44.3%	46.9%	48.3%	39.6%
Educational Attainment				
Less than high school	12.0%	18.6%	14.3%	8.2%
High school graduate or GED	35.5%	37.2%	39.6%	30.9%
Some college	26.1%	19.2%	21.4%	32.4%
College or more	26.4%	25.0%	24.7%	28.5%

Notes: [a] 1=none or few; 5= 200 or more books; [b] 1=excellent; 5=poor; [c] 1=much better; 5= much worse

Figure 1: Mean cognitive functioning by age and birth cohort, Health and Retirement Study (1998-2012), LHMS Sample

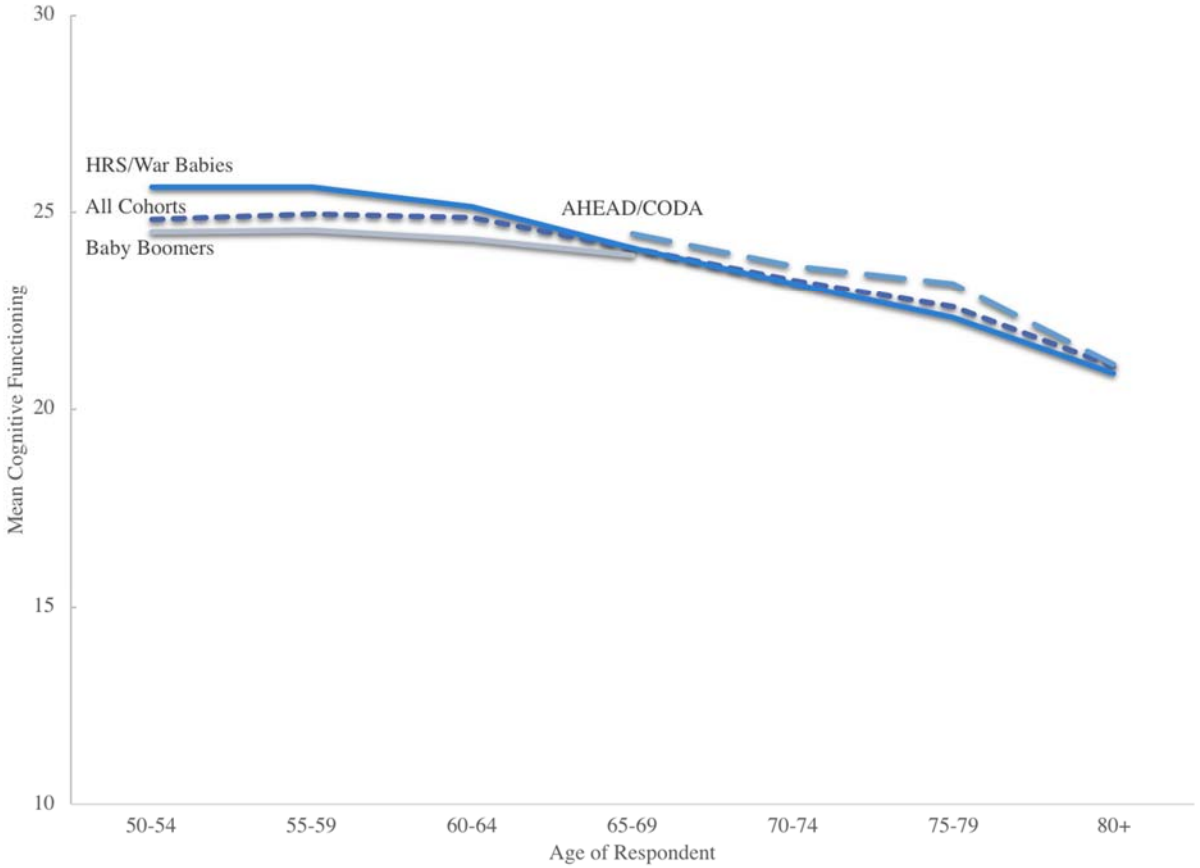

Table 2: Linear random coefficient models predicting cognitive functioning by educational attainment and schooling experiences, Health and Retirement Study (1998-2012), LHMS sample

	Model 1 b (SE)	**Model 2** b (SE)	**Model 3** b (SE)
At age 65	25.79* (0.14)	26.47* (0.23)	27.19* (0.22)
Educational Attainment [a]			
Less than high school	-4.16* (0.14)		-3.24* (0.15)
High school graduate or GED	-1.97* (0.10)		-1.53* (0.10)
Some college	-1.03* (0.10)		-0.80* (0.10)
School Experiences			
Diagnosed learning problem		-1.10* (0.13)	-0.97* (0.12)
Class size less than 30 students		0.35* (0.10)	0.29* (0.10)
Reading ability compared to peers [b]		-0.29* (0.05)	-0.20* (0.04)
Math ability compared to peers [b]		-0.53* (0.05)	-0.47* (0.04)
Majority non-White elem. school		-0.59* (0.20)	-0.60* (0.19)
Language or creative arts		0.81* (0.09)	0.41* (0.09)
High school curriculum [a]			
Never attended high school		-2.63* (0.31)	-1.27* (0.31)
Vocational or general education		-0.40* (0.09)	-0.09 (0.09)
Lived in rural area during school		-0.46* (0.07)	-0.35* (0.07)
Age [c]	-0.17* (0.01)	-0.17* (0.02)	-0.17* (0.02)
Educational Attainment [a]			
Less than high school x age	-0.014 (0.01)		-0.008 (0.01)
High school graduate or GED x age	0.0004 (0.01)		0.002 (0.01)
Some college x age	-0.013 (0.01)		-0.013 (0.01)
School Experiences			
Diagnosed learning problem x age		-0.01 (0.01)	-0.003 (0.01)
Class size less than 30 students x age		0.003 (0.01)	0.001 (0.01)
Reading ability compared to peers x age [b]		-0.003 (0.004)	-0.003 (0.004)
Math ability compared to peers x age [b]		0.001 (0.004)	0.002 (0.004)
Majority non-White elem. school x age		0.01 (0.02)	0.01 (0.02)
Language or creative arts x age		0.002 (0.01)	0.003 (0.01)
High school curriculum [a]			
Never attended high school x age		-0.01 (0.02)	-0.003 (0.02)
Vocational or general education x age		0.00 (0.01)	0.002 (0.01)
Lived in rural area during school x age		-0.01 (0.01)	-0.01 (0.01)
Random intercept (at mean age)	-2.24* (0.04)	-2.23* (0.04)	-2.25* (0.04)
Random slope (age)	0.82* (0.01)	0.83* (0.01)	0.77* (0.01)
Within-person error	0.96* (0.004)	0.96* (0.004)	0.96* (0.004)
Number of respondents		6,056	
Person-period observations		38,452	
Mean number of observations		6.3	

Notes: [a] Referent groups – college or above, college preparatory coursework; [b] 1=Much better, 5=Much worse; [c] Age centered at 65. All models adjust for gender, race/ethnicity, birth cohort, proxy interview in 2015, parents' education, number of books in house during childhood, and self-reported health in childhood.

Table 3: Cohort stratified linear random coefficient models predicting cognitive functioning by educational attainment and schooling experiences, Health and Retirement Study (1998-2012), LHMS sample

	AHEAD/CODA	**HRS/War Babies**	**Boomers**
	b (SE)	b (SE)	b (SE)
At mean age [a]	24.47* (0.76)	27.08* (0.31)	27.24* (0.33)
Educational Attainment [b]			
Less than high school	-3.3* (0.45)	-3.04* (0.20)	-3.48* (0.24)
High school graduate or GED	-0.36 (0.33)	-1.54* (0.14)	-1.80* (0.15)
Some college	-0.04 (0.35)	-0.87* (0.14)	-0.83* (0.14)
School Experiences			
Diagnosed learning problem	-0.47 (0.50)	-0.84* (0.18)	-1.14* (0.15)
Class size less than 30 students	-0.34 (0.34)	0.33* (0.13)	0.35* (0.14)
Reading ability compared to peers [c]	-0.40* (0.17)	-0.25* (0.06)	-0.08 (0.06)
Math ability compared to peers [c]	-0.23 (0.16)	-0.50* (0.06)	-0.45* (0.06)
Majority non-White elem. school	-0.22 (0.76)	-0.62* (0.30)	-0.71* (0.21)
Language or creative arts	0.31 (0.31)	0.47* (0.12)	0.35* (0.13)
High school curriculum [b]			
Never attended high school	-0.73 (0.76)	-1.70* (0.39)	-0.72 (0.60)
Vocational or general education	-0.06 (0.34)	-0.09 (0.13)	-0.13 (0.12)
Lived in rural area during school	-0.09 (0.24)	-0.46* (0.10)	-0.20 (0.11)
Age [a]	-0.27* (0.01)	-0.17* (0.00)	-0.01 (0.01)
Random intercept (at mean age)	-1.66* (0.06)	-2.08* (0.04)	-2.65* (0.46)
Random slope (age)	0.85* (0.04)	0.79* (0.02)	0.78* (0.02)
Within-person error	0.98* (0.01)	0.95* (0.01)	0.95* (0.01)
Number of respondents	548	2,810	2,698
Person-period observations	4,613	23,163	10,676
Mean number of observations	8.4	8.2	4.0

Notes: [a] Age centered at mean age of cohort (AHEAD/CODA = 79; HRS/War Babies = 66; Boomers = 57). [b] Referent groups – college or above, college preparatory coursework; [c] 1=Much better, 5=Much worse; All models adjust for gender, race/ethnicity, birth cohort, proxy interview in 2015, parents' education, number of books in house during childhood, and self-reported health in childhood.

Supplemental Table 1: Sample composition of LHMS sample versus HRS sample, 1998-2014

	Full Sample	**LHMS Sample**
	n=24,111	n=6,056
Cognitive Functioning [a]		
0 to 10	2.0%	0.3%
11 to 14	6.3%	2.3%
15 to 24	55.6%	47.9%
25 to 35	36.1%	49.5%
Age [a]		
55 to 64	33.7%	45.2%
65 to 74	32.5%	36.0%
75+	33.8%	18.7%
Gender		
Men	44.2%	40.8%
Women	55.8%	59.2%
Race/Ethnicity		
Non-Hispanic White	67.7%	74.4%
Non-Hispanic Black	17.6%	17.6%
Latino	12.0%	5.2%
Other	2.7%	2.8%
Birth Cohort		
AHEAD / CODA	32.8%	9.0%
HRS / War Babies	38.6%	46.4%
Boomers	28.6%	44.6%
Education		
Less than High School	26.1%	12.0%
High School or GED	33.8%	35.5%
Some College	22.0%	26.1%
College or Higher	18.0%	26.4%

Notes:
[a] Average percentage from 1998 - 2014

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