HHS Public Access
Author manuscript
Ann Epidemiol. Author manuscript; available in PMC 2016 January 06.

Published in final edited form as:
Ann Epidemiol. 2011 February ; 21(2): 128–138. doi:10.1016/j.annepidem.2010.11.004.

The association between blood pressure and years of schooling versus educational credentials: Test of the sheepskin effect

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Abstract

Purpose—Attaining a degree may offer greater opportunities for health than years of schooling alone. This study examines whether there is a degree, or “sheepskin”, effect on the association between education and blood pressure.

Methods—Multivariable-adjusted ordinal and linear regression models assessed associations of years of schooling and degree attainment with systolic and diastolic blood pressure in a sample of 552 adults aged 38–47 years.

Results—Years of schooling was inversely associated with systolic blood pressure adjusting for age, gender and race (β=−0.4, 95% CL:−0.7,−0.1 mmHg systolic blood pressure/year of schooling). Additional adjustment for mother’s education, childhood verbal intelligence quotient, childhood health and childhood socioeconomic status had minimal impact on effect size (β= −0.3, 95% CI=−0.7,0.0). However, years of schooling was no longer associated with blood pressure in the fully adjusted model which included additional adjustment for degree attained (β=0.0, 95% CL:−0.5, 0.4). In the fully adjusted model (including adjustment for years of schooling), individuals with a graduate degree still had significantly lower systolic blood pressure than HS degree-holders (e.g. β=−9.2, 95% CL:−15.2,−3.2 for graduate vs. high school degree). Findings were similar for diastolic blood pressure.

Conclusion—The association of years of schooling with blood pressure may be largely due to degree attainment rather than simply the knowledge and skills accumulated due to years of schooling alone.

Keywords

Educational status; education classification; cohort study; blood pressure

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INTRODUCTION

Pre-hypertension and hypertension are widely prevalent and well-known risk factors for cardiovascular disease (CVD) and mortality (1–4). Previous research suggests that educational status is inversely associated with blood pressure and risk of hypertension (5–7), even after adjusting for income and other measures of socioeconomic status (8–9). However, education is typically characterized using only years of schooling or degree attainment, but not both. Years of schooling and degree attainment differ importantly in their conceptualization of the underlying mechanisms linking education to health (10). “Years of schooling” implies that quantity matters, with each year leading to incremental increases in an individual’s knowledge and skills (11–12), independent of the highest degree attained. By contrast, a degree may signal greater knowledge or skill given similar years of schooling. Degree holders may also have greater social prestige than non-degree holders with the same years of schooling (12). The difference between those with a degree and those without a degree who have the same years of schooling is often called a “sheepskin effect”.

Previous research on sheepskin effects have largely focused on economic outcomes such as wages. Sheepskin effects for wages have consistently been found in diverse settings (13–14). In one of the first studies to test for sheepskin effects in wages, Hungerford and Solon (1987) found significantly larger returns to years of schooling traditionally associated with a diploma in the United States (e.g. 12 years=HS degree, 16 years=BA/BS) compared to increases associated with other years of schooling typically associated with a degree (e.g. 14 years, 15 years) (15). Subsequent studies which used information on both years of schooling and degree attainment found larger sheepskin effects compared to other studies that used years of schooling alone (16–17).

Despite the extensive research documenting the inverse relationship between education and blood pressure, it is unclear whether there is a sheepskin effect for health. One study which included a separate variable for each year of schooling to assess if there were discontinuities in the years of schooling that correspond to standard degree completion (e.g., 12 years, l6 years) did not find any evidence of a sheepskin effect for most health conditions including blood pressure (18). However, there is very little information on the sheepskin effects on blood pressure where degree attainment and years of schooling were both directly assessed (rather than degree attainment estimated using years of schooling alone). Consequently, the primary objective of this study is to examine whether degree attainment is associated with an additional health benefit beyond years of schooling using a dataset with detailed information on years of schooling, degree attainment, and childhood characteristics. We also evaluated whether adulthood smoking, body mass index (BMI) or income, factors commonly associated with lower blood pressure and education, mediate the relationship between education and blood pressure.

METHODS

Sample

Participants were the children of pregnant women enrolled in the Rhode Island and Massachusetts sites of the Collaborative Perinatal Project (CPP) between 1959 and 1966

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(19–20). Participants in the Massachusetts and Rhode NCPP cohorts had similar occupational and educational levels as the overall population in the 1960 US Census (20). The Transdisciplinary Tobacco Use Research Center: New England Family Study (TTURC:NEFS) project interviewed approximately 10% of these participants as adults in 1999 (21). A subsample of these TTURC:NEFS participants provided additional information in the EdHealth Study (n=618), conducted between 2004 through 2007 and designed to look in detail at pathways by which education influences health. Participants in EdHealth were selected with preference for non-white participants and sibling pairs who were discordant on attained level of education. The final sample (n=552) for the current study was restricted to EdHealth participants who had complete data on all key study variables. Survey weights were not included in this analysis. We excluded 66 participants who did not have blood pressure readings because they completed phone interviews (n=41) or refused (n=25). There were no significant differences between included and excluded participants for gender, race, mother's educational level, childhood socioeconomic status or childhood health ($p>0.05$). Included participants had an average childhood verbal IQ that was higher than those who were excluded (verbal IQ score of 103.6 vs. 98.5, $p=0.01$). All participants provided informed consent. This study was approved by IRB review at both Harvard and Brown University.

Outcome variables

Blood pressure was our outcome of interest. Systolic and diastolic blood pressure were measured for seated participants, after a 5 minute rest, in their right arm resting at heart level, using automated blood pressure monitors (VSMedTech BpTru, Coquitlam, BC, Canada) that have been demonstrated to have good validity and reliability compared with the auscultation method (22). Five blood pressure readings were obtained in 1 minute intervals. Systolic and diastolic blood pressure values were calculated as the mean of the lowest three blood pressure readings, excluding the first recorded blood pressure. Blood pressure was categorized as both a continuous and a categorical variable (systolic blood pressure: 0–119 mmHg, 120–139 mmHg, ≥140 mmHg; diastolic blood pressure: 0–79 mmHg, 80–89 mmHg, ≥90 mmHg). Cutpoints reflect standard definitions of normal, prehypertension and hypertension, respectively (23).

Exposure variables

We examined two different dimensions of education, specifically years of schooling and degree attainment. Years of schooling was calculated by summing respondent's self-reported last completed grade in secondary school with self-reported years of schooling for each post-secondary school attended. For example, individuals who completed grade 12 and did not attend a post-secondary school were categorized as having a total of 12 years of schooling. Individuals with a GED were credited with the last completed grade plus self-reported completed years of schooling for each post-secondary school attended. This continuous variable was centered on the sample mean (15 years of schooling). Degree attainment reflected self-reported highest degree completed: less than HS, HS degree/GED, certificate, associate's degree (e.g. AA), bachelor's degree (e.g. BA, BS), and graduate degree (e.g. JD, MD, MS, MSW). HS diploma and GED holders were grouped together due

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to the small number of individuals with a GED (n=27) and because both groups conceptually possess the basic cognitive skills associated with a HS degree.

Potential confounders

The following potential confounders were included in our analysis: age, gender, race/ethnicity (Non-White vs. White), mother's education (More than HS degree vs. HS degree or less), cognitive aptitude (verbal IQ at age 7), childhood chronic health condition at age seven (yes/no) and childhood socioeconomic status (SES) at age seven. Mother's education was included as a potential confounder because it has been previously found to be strongly associated with the child's subsequent educational attainment and adult health status (24). Childhood SES is a composite index adapted from the Bureau of the Census based on the family income and the education and occupation of the head of the household (25) and ranged from 0 (low) to 9.3 (high) in our sample. Childhood chronic disease was included to account for potential reverse causality whereby poor health as a child may lead to both lower educational attainment and adult poor health (26). Childhood chronic disease was based on mothers' self-reports, presence of any chronic health conditions noted in medical records, or diagnosis by study physicians during study physical examinations (27). Verbal IQ was measured using the Wechsler Intelligence Scale for Children (WISC), a standard measure with excellent reliability and validity (28), when the individual was 7 years old and age-standardized with a mean IQ score of 100 and an SD of 15 in the general population. Verbal IQ at 7 years of age should be largely unaffected by the effects of education since most individuals at that age had just started formal schooling. All of the continuous variables were mean centered so the intercept represents the outcome when all independent variables are at their mean values.

Potential mediators

We examined three factors commonly reported to be associated with lower blood pressure and plausibly related to higher educational status as potential mediators - current income, daily cigarette intake, and BMI (29–31). Each individual was assigned the mean income in their categorical response. For example, we assumed individuals whose self-reported family income was between 25,000 and 34,999 made approximately 30,000. Body mass index (BMI) was calculated as weight in kilograms/(height in meters)^2. Self-reported cigarette smoking was coded as a continuous variable (number of cigarettes per day).

Statistical Analysis

Results were contrasted from linear and ordinal logistic regression models. Linear regression estimated the change in the population average of the outcome conditional on the given covariates in separate models for years of schooling or degree attainment, and in models which included information on both years of schooling and degree attainment. Individuals with a HS Degree/GED were the reference group in the models with degree attainment. Assumptions of conditional normality and constant variance were tested and met for the linear regression models. Separate models were run for diastolic and systolic blood pressure. Results are presented for males and females combined due to the lack of statistical evidence that the effect differed by gender (p-value for likelihood ratio test comparing models with *vs.*

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without interaction terms for sex=0.75 for systolic blood pressure, and 0.60 for diastolic blood pressure respectively).

We assessed whether current income, BMI, and cigarette intake were mediators in the relationship between education and health using a multiple mediation model. This model simultaneously estimates the association between each mediator and the education exposure, along with the change in the outcome associated with the mediator in the fully adjusted model and calculates an indirect effect using the product of coefficients method (32–33). The indirect effect is the reduction in the association of the exposure on the outcome due to the potential mediator. We summed the indirect effects for each individual mediator to estimate the total indirect effect. Examining the individual indirect effect provides evidence of whether education exerts its effects uniquely through any of the mediators examined in this study (32). Confidence intervals (CI) were estimated using the bias-corrected bootstrapping procedure with 5000 resamples adjusted for clustering from individuals in the same family. Bootstrapping avoids the common mistaken assumptions that the indirect effects are normally distributed and symmetrical (34). Statistical significance was determined by examining whether zero was within the 95% CI.

Ordinal regression models estimated odds of being in a given category or beyond (e.g. normal *vs.* pre-hypertensive/hypertensive and normal/pre-hypertensive *vs.* hypertensive) where the effects of all covariates are assumed to be constant across all outcome categories. The proportional odds assumption for these models was confirmed using either the Brant test or the likelihood ratio test.

RESULTS

Of the study participants (n=552), 78% were White and 60% were female, with a mean of 15 years of schooling. Approximately 92% of the respondents received at least a high school diploma/GED, Table 1). Higher educational credentials were associated with more years of schooling (Table 1). The coefficient of variation, the ratio of the standard deviation to the mean, across highest reported degree indicated there was variation in years of schooling within each degree category (range 14–27). For example, among individuals whose highest reported degree was a high school diploma or GED, 52% had 12 years of schooling, 35% had more than 12 years of schooling and 13% had less than 12 years of schooling (Appendix A).

Mean blood pressures for the study sample were 115 mmHg (SD=16 mmHg) systolic and 76 mmHg (SD=11 mmHg) diastolic (Table 1). Mean blood pressure for each degree category varied significantly ($p<0.01$) with higher degree holders generally having lower blood pressure (e.g. average systolic BP for high school *vs*. graduate degree was 118 *vs.* 108 mmHg, respectively). Average BMI and cigarette smoking also varied, with higher degree holders having lower mean BMI and smoking fewer cigarettes per day ($p<0.05$).

Years of schooling were inversely associated with systolic and diastolic blood pressure in the unadjusted and partially adjusted models (Table 2). Each year of schooling was associated with an average decrease of 0.4 mmHg systolic blood pressure (95% CL=

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−0.7,0.1, Table 2) and an average decrease of 0.2 mmHg diastolic blood pressure (95% CL= −0.4,0.1, Table 2) in the models adjusted for age, gender, and race. This estimate was only slightly attenuated when childhood characteristics (i.e. verbal IQ, presence of chronic health condition, and family SES at age seven) were included in the models (β=−0.3 mmHg (95% CL=−0.7,0.0) for systolic blood pressure and β=−0.2 mmHg (95% CL=−0.5,0.0) for diastolic blood pressure, Table 2). By contrast, the estimate for years of schooling was greatly reduced in the fully adjusted models which included demographic characteristics, childhood characteristics and highest degree attained (β=0.0 mmHg (95% CL=−0.5,0.4) for systolic blood pressure and β=0.0 mmHg (95% CL=−0.2,0.3) for diastolic blood pressure, Table 2). Models which substituted father's education for childhood socioeconomic status did not significantly change effect estimates (Appendix B).

Degree attainment was inversely associated with systolic and diastolic blood pressure after adjusting for age, gender, race, mother's education, childhood verbal IQ, childhood chronic health conditions and childhood SES (e.g. β=−9.3, 95% CL:−14.3,−4.2 mmHg systolic blood pressure, β=−6.1, 95% CL:−10.0,−2.2 mmHg diastolic blood pressure for graduate degree vs. high school degree; Table 2). Importantly, the effect estimate for degree attainment in the fully adjusted model was similar to the effect estimates in the earlier models (β=−9.2, 95% CL:−15.2,−3.2 mmHg systolic blood pressure; β=−6.7, 95% CL: −10.8,−2.5 diastolic blood pressure; Table 2). To assess whether these results reflect residual confounding by IQ we conducted further analysis stratified by median split of verbal IQ at age 7 and found similar estimates (Appendix C). Moreover, estimates were similar when we conducted the analysis on a restricted sample of participants who were not currently on any BP medications (Appendix D).

Table 3 depicts the parameter estimates for the total and the specific indirect effects between years of schooling and blood pressure as mediated by current family income, cigarette intake and BMI. In the unadjusted models, the significant indirect effect for BMI (e.g. estimate= −2.4, 95% CL:−4.2,−0.6 for graduate *vs*. HS degree) suggest that BMI may partially mediate the association between education and hypertension. However, these effects were no longer statistically significant in the fully adjusted models, suggesting that education does not have a unique effect on blood pressure through BMI in mid-life once individual-level characteristics are included.

In the ordinal regression models, only graduate degree was associated with significantly lower odds of being in a higher blood pressure category (OR=0.13, 95% CL=0.03,0.52 for systolic blood pressure; OR=0.17, 95% CL=0.05,0.59 for diastolic blood pressure; Table 4). Estimates from models where the sample was restricted to individuals who were not on any medications for hypertension were similar (Appendix E).

DISCUSSION

This study suggests there may be a sheepskin effect for the association of education with systolic and diastolic blood pressure. Specifically, the association of years of schooling with blood pressure was markedly reduced after adjusting for educational degree attainment,

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while the association of educational degree attainment with blood pressure was not affected by adjusting for years of schooling.

Our findings of inverse associations between years of schooling and blood pressure accounting for commonly adjusted confounders (i.e. age, gender, and race) were similar to previous studies on measures of socioeconomic status and blood pressure (6–7, 35–37). For example, one study with a population sample from 29 countries found that every additional year of education was associated with a decrease of 0.13 mmHg in systolic pressure for men (6). However, to the best of our knowledge, this is the first study to examine the association between education and measured blood pressure adjusting for early life characteristics (i.e. childhood verbal IQ, childhood health and childhood socioeconomic status) and using information on both years of schooling and degree attainment. Our study results suggest that childhood potential common prior causes account for a small proportion of the effect size, while degree attainment accounts for a large amount of the effect for the association of years of schooling with blood pressure. Adjusting for years of schooling has very little impact on associations of educational degree attainment with blood pressure.

Credential effects suggest other mechanisms link education and health besides simple knowledge accumulation. Degree-holders may have learned more than non-degree holders with the same number of years of schooling. Alternatively, degree-holders may have accumulated more material resources (e.g. better housing), more psychosocial resources (e.g. greater prestige within a community, greater personal control over daily life), or better health literacy as a result of their degree (38). One twin study found that individuals in a working class profession had significantly higher systolic and diastolic blood pressure compared to their professional twins (37).

In this study, we did not find evidence that current income, smoking, or body mass index mediated this relationship in the fully adjusted models. Previous research on whether the association between education and blood pressure is mediated by BMI has been mixed. One study reported that adult BMI did not explain the difference in prevalence of hypertension by education in males (1). Other studies found that BMI and/or waist circumference accounted for a reduction in the education–blood pressure coefficient ranging from approximately 28% to 50% (39–40). These wide –ranging meditational estimates of BMI may be due to differences in the methods used by each of these studies (e.g. assessing differences in the effect estimate size associated with the exposure in models with and without the mediator vs. assessing indirect effects through the mediator). In addition, our results may differ from previous research because of the comprehensive confounders that we were able to control for (e.g. childhood characteristics). Efforts to quantify the direct and indirect effects of education race on hypertension risk rely on strong assumptions including 1) the mediators are themselves unconfounded and; 2) the mediators do not modify the strength of the direct effects of the exposure on the outcome (41) and standard epidemiological methods to estimate an indirect effect through a mediator (e.g. stratifying the exposure-disease association by values of the hypothesized mediator) may still lead to biased estimates (42). In addition, income or health behaviors at earlier ages may be more important in the relationship between education and blood pressure in mid-life than current status. Alternatively, other mechanisms which were not available in our study may account

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for the association through individual behavior (e.g. dietary intake) or individual psychosocial factors (e.g. hostility, social isolation and stress) or neighborhood conditions (e.g. crowding and noise, 43–45).

Our study had several limitations. Firstly, reverse causality where poor childhood health leads to low educational levels and poor adult health is a potential alternative explanation of our results. However, we attempted to minimize this possibility by using a prospective cohort study design and adjusting for presence of childhood chronic illness. Similarly we also adjusted for cognitive ability, another plausible confounder which is known to be strongly associated with both years of education and degree attainment. Despite these efforts, there may still be residual confounding, such as genetic heterogeneity, unaccounted for in our study. Thirdly, since our sample is relatively young and the prevalence of hypertension increases dramatically among adults 60 years and older (46), our sample may be reflecting earlier onset of high blood pressure. Finally, our results may have limited generalizability. The health returns associated with degree attainment will depend on the larger social context (i.e. the value of a degree will vary according to culture and time).

Strengths of this study include the ability of our analyses to statistically adjust for directly assessed infrequently measure common prior causes, such as childhood intelligence, childhood chronic health conditions and childhood socioeconomic status, thereby reducing the potential confounding impact of these factors. Furthermore, extensive quality control/ quality assurance protocols were utilized for the biological and questionnaire measures, thereby improving the accuracy of the constructs assessed in this study.

These findings suggested that degree attainment may be substantially more important than years of schooling in predicting systolic and diastolic blood pressure. Despite the high rates of high school graduates going to college, only about half of college students in the United States graduate within six years with even lower rates of college completion for socially disadvantaged students (47). Persistent low levels of educational attainment in the US (48) may be perpetuating health disparities in hypertension and subsequent cardiovascular risk because even small decreases in the average blood pressure have important public health consequences. According to one estimate, a reduction of 2 mmHg in the average diastolic BP in the United States population could translate to a 17% lower prevalence of hypertension and a 15% lower risk of stroke (49). In this manner, educational policy that focuses on increasing educational attainment may have far-reaching health consequences. From a policy standpoint, identifying key aspects of degree attainment that are strongly associated with health provides a crucial point for intervention.

List of abbreviations

CVD	Cardiovascular disease
CPP	Collaborative Perinatal Project
BMI	Body mass index

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TTURC:NEFS	Transdisciplinary Tobacco Use Research Center: New England Family Study
e.g. AA	Associate's degree
e.g. BA, BS	Bachelor's degree
SES	Socioeconomic status
WISC	Wechsler Intelligence Scale for Children
CI	Confidence intervals

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Appendix A: Cross tabulation of highest degree received by years of completed education

	Highest degree attained						
Years of schooling	**< HS degree**	**HS/GED**	**Certificate**	**Associate's**	**BA/BS**	**Graduate**	**Total**
Unknown (n)	**7**	**3**	**11**	**0**	**0**	**0**	**21**
Row %	*33*	*14*	*52*	*0*	*0*	*0*	
Column %	16	2	9	0	0	0	
Less than 12 (n)	**26**	**19**	**12**	**2**	**1**	**0**	
Row %	43	32	20	3	2	0	
Column %	68	13	11	2	1	0	
12 years (n)	**5**	**76**	**22**	**0**	**0**	**0**	**103**
Row %	*5*	*74*	*21*	*0*	*0*	*0*	
Column %	13	51	18	0	0	0	

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	Highest degree attained						
Years of schooling	**< HS degree**	**HS/GED**	**Certificate**	**Associate's**	**BA/BS**	**Graduate**	**Total**
13 years (n)	**5**	**18**	**22**	**2**	**0**	**0**	**47**
Row %	*11*	*38*	*47*	*4*	*0*	*0*	
Column %	13	12	18	2	0	0	
14 years (n)	**0**	**16**	**20**	**21**	**0**	**0**	**57**
Row %	*0*	*28*	*35*	*37*	*0*	*0*	
Column %	0	11	16	22	0	0	
15 years (n)	**0**	**4**	**20**	**19**	**1**	**0**	**44**
Row %	*0*	*9*	*45*	*43*	*2*	*0*	
Column %	0	3	16	20	1	0	
16 years (n)	**0**	**7**	**4**	**14**	**31**	**0**	**56**
Row %	*0*	*13*	*7*	*25*	*55*	*0*	
Column %	0	5	3	15	30	0	
17 years (n)	**1**	**1**	**1**	**10**	**14**	**0**	**27**
Row %	*4*	*4*	*4*	*37*	*52*	*0*	
Column %	3	1	1	11	13	0	
18 years (n)	**1**	**3**	**2**	**13**	**23**	**4**	**46**
Row %	2	7	4	28	50	9	
Column %	3	2	2	14	22	11	
≥ 19 years (n)	**0**	**3**	**9**	**14**	**34**	**31**	**91**
Row %	*0*	*3*	*10*	*15*	*37*	*34*	
Column %	0	2	7	14	33	89	
Total	**45**	**150**	**123**	**95**	**104**	**35**	**552**
Row %	*8*	*27*	*22*	*17*	*19*	*6*	

Appendix B: Association of years of schooling and degree attainment with blood pressure from linear regression models (95% CL)

	Systolic Blood Pressure		*Diastolic Blood Pressure*	
	Model 3[d]	**Model 4[e]**	**Model 3[d]**	**Model 4[e]**
Years of schooling	**−0.3 (−0.7, 0.1)**	**0.0 (−0.4, 0.4)**	**−0.2 (−0.4, 0.1)**	**0.1 (−0.2, 0.4)**
Degree attainment				
Less than HS	−6.7 (−12.5, −0.9)	−4.3 (−10.4, 1.9)	−2.1 (−6.9, 2.7)	0.0 (−4.9, 5.0)
HS degree/GED	Reference	Reference	Reference	Reference
Certificate	0.1 (−4.5, 4.7)	0.2 (−4.5, 4.8)	−0.4 (−3.6, 2.9)	−0.3 (−3.5, 2.9)
Associate's	−3.2 (−7.4, 1.0)	−3.2 (−7.5, 1.1)	−1.2 (−4.1, 1.8)	−1.6 (−4.6, 1.4)
Bachelor's	−4.0 (−7.8, −0.1)	−4.0 (−8.3, 0.3)	−2.8 (−5.6, −0.1)	−3.4 (−6.2, −0.5)
Graduate	−9.7 (−14.8, −4.7)	−9.9 (−15.9, −4.0)	−6.2 (−10.1, −2.2)	−7.1 (−11.3, −2.9)

[d]Model 3: Adjusted for age, gender, race, mother's education, childhood verbal IQ, childhood health and father's edudcation

[e]Model 4: Adjusted for age, gender, race, mother's education, childhood verbal IQ, childhood health, father's education, years of schooling and degree attainment

Appendix D: Association of years of schooling and degree attainment with blood pressure from linear regression models (95% CL) for individuals not currently on BP medications

	Systolic Blood Pressure		*Diastolic Blood Pressure*	
	Unadjusted	**Adjusted[g]**	**Unadjusted**	**Adjusted[g]**
Years of schooling	**−0.4(−0.8, −0.1)**	**0.1 (−0.4, 0.5)**	**−0.2 (−0.5, 0.0)**	**0.1 (−0.2, 0.4)**
Degree attainment				
Less than HS	0.2 (−4.8, 5.1)	0.5 (−5.3, 6.2)	1.4 (−2.7, 5.5)	4.0 (−1.1, 9.0)
HS degree/GED	Reference	Reference	Reference	Reference
Certificate	1.5 (−3.0, 6.1)	−0.2 (−5.5, 5.2)	0.8 (−2.4, 4.0)	−0.5 (−4.2, 3.3)
Associate's	−4.3 (−8.3, −0.4)	−2.8 (−7.4, 1.8)	−2.3 (−5.1, 0.5)	−1.2 (−4.4, 2.0)
Bachelor's	−4.5 (−8.5, −0.4)	−5.4 (−9.9, −0.9)	−2.5 (−5.4, 0.4)	−3.9 (−7.1, −0.7)
Graduate	−8.2 (−13.3, −3.1)	−9.7 (−15.9, −3.4)	−4.3 (−8.3, −0.3)	−6.4 (−11.0, −1.7)

[g]Adjusted for age, gender, race, mother's education, childhood verbal IQ, childhood health, childhood SES, years of schooling and degree attainment

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Table 1

Descriptive characteristics by highest degree attained, EdHealth Study [a]

	Highest degree attained						
	< HS degree	**HS/GED**	**Certificate**	**Associate's**	**BA/BS**	**Graduate**	**p-value**
N	45	150	123	95	104	35	
Years of schooling	11 (3)	13 (3)	14 (4)	16 (2)	18 (4)	21 (4)	<0.01
Coefficient of variation	27	20	27.4	15	20	18	
Age, years	42 (1)	42 (2)	43 (2)	42 (2)	42 (2)	42 (2)	0.72
Childhood SES	4 (2)	5 (2)	5 (2)	6 (2)	6 (2)	7 (2)	<0.01
Verbal IQ at age 7	85 (16)	97 (13)	98 (14)	98 (11)	104 (12)	111 (16)	<0.01
Non-Hispanic White, %	63	80	70	91	77	89	<0.01
Male, %	38	46	42	28	42	34	0.13
Childhood chronic infection, %	14	11	15	21	15	12	0.50
Mother's education > HS degree, %	19	18	24	28	41	55	<0.01
Current family income ≥ 50,000, %	8	24	29	33	59	64	<0.01
Adult health outcomes							
Systolic BP, mmHg	117 (14)	118 (19)	119 (18)	113 (14)	113 (15)	108 (11)	<0.01
Pre-high/high SBP, %	31	37	38	29	29	14	0.08
Diastolic BP, mmHg	78 (12)	77 (12)	78 (13)	75 (10)	74 (10)	72 (9)	<0.01
Pre-high/high DBP, %	42	37	41	26	32	14	0.02
Currently on BP meds, %	7	11	12	7	12	3	0.5
Mean BMI	31 (9)	29 (6)	31 (9)	29 (6)	29 (7)	26 (5)	<0.01
Obese, %	58	36	42	35	36	16	0.02
Mean cigarette intake, # per day	7 (9)	5 (10)	5 (9)	4 (7)	2 (6)	0.2 (0.8)	<0.01

[a]Point estimates shown as means or proportions (standard deviations). p-value for non-parametric test of trend across ordered educational attainment groups for continuous variables and for chi-square for categorical variables

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Table 2

Association of years of schooling and degree attainment with blood pressure from linear regression models (95% CL)

		Systolic Blood Pressure				*Diastolic Blood Pressure*			
	n	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**
Years of schooling	**531**	**−0.5 (−0.8, −0.1)**	**−0.4 (−0.7, −0.1)**	**−0.3 (−0.7, 0.0)**	**−0.0 (−0.5, 0.4)**	**−0.3 (−0.5, −0.0)**	**−0.2 (−0.4, 0.0)**	**−0.2 (−0.5, 0.0)**	**0.0 (−0.2, 0.3)**
Degree attainment									
Less than HS	45	−0.8 (−5.9, 4.2)	−0.8 (−6.0, 4.4)	−3.6 (−8.7, 1.5)	−2.3 (−7.7, 3.2)	0.7 (−3.3, 4.7)	1.5 (−2.5, 5.4)	−0.2 (−4.6, 4.3)	1.2 (−3.5, 5.8)
HS degree/GED	150	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Certificate	123	0.9 (−3.6,5.4)	0.0 (−4.4, 4.4)	0.7 (−3.8, 5.2)	0.8 (−3.8, 5.4)	0.3 (−2.8, 3.3)	0.0 (−3.0, 3.1)	−0.1 (−3.4, 3.1)	−0.0 (−3.2, 3.2)
Associate's	95	−5.2 (−9.2, −1.2)	−3.3 (−7.1, 0.6)	−3.4 (−7.5, 0.8)	−3.2 (−7.5, 1.1)	−2.8 (−5.6, 0.0)	−1.4 (−4.1, 1.4)	−1.8 (−4.7, 1.1)	−2.0 (−4.9, 1.0)
Bachelor's	104	−4.7 (−8.8, −0.5)	−4.5 (−8.3, −0.7)	−3.8 (−7.6, 0.0)	−3.7 (−8.0, 0.6)	−2.9 (−5.7,−0.1)	−2.7 (−5.3, 0.0)	−3.0 (−5.7, −0.3)	−3.3 (−6.2, −0.5)
Graduate	35	−10.0 (−15.1, −4.9)	−8.9 (−13.7, −4.0)	−9.3 (−14.3, −4.2)	−9.2 (−15.2, −3.2)	−5.6 (−9.5, −1.8)	−4.9 (−8.5, −1.4)	−6.1 (−10.0, −2.2)	−6.7 (−10.8, −2.5)

[b] Model 1: Unadjusted

[c] Model 2: Adjusted for age, gender and race

[d] Model 3: Adjusted for age, gender, race, mother's education, childhood verbal IQ, childhood health and childhood SES

[e] Model 4: Adjusted for age, gender, race, mother's education, childhood verbal IQ, childhood health, childhood SES, years of schooling and degree attainment

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Table 3

Estimated indirect effect with 95% CL for education and blood pressure through current family income, cigarette intake and BMI [f]

	Systolic BP		Diastolic BP	
	Years of schooling	**Graduate degree**	**Years of schooling**	**Graduate degree**
Unadjusted				
BMI	−0.2 (−0.3, 0.0)	−2.4 (−4.2, −0.6)	−0.1 (−0.2, 0.0)	−1.2 (−2.4, −0.3)
Income	0.1 (0.0, 0.2)	0.5 (0.0, 1.8)	0.0 (0.0, 0.1)	0.3 (0.0, 1.4)
Cigarette intake	0.0 (−0.1, 0.1)	0.0 (−0.8, 0.7)	0.0 (−0.1, 0.0)	−0.2 (−0.8, 0.4)
Total indirect effect	−0.1 (−0.3, 0.1)	−1.9 (−4.0, 0.6)	−0.1 (−0.2, 0.0)	−1.1 (−2.4, 0.3)
Adjusted				
BMI	−0.1 (−0.4, 0.1)	−1.1 (−3.1, 0.8)	0.0 (−0.2, 0.1)	−0.6 (−1.7, 0.4)
Income	0.0 (0.0, 0.1)	0.3 (−0.2, 1.8)	0.0 (0.0, 0.1)	0.2 (−0.1, 1.4)
Cigarette intake	0.0 (0.0, 0.1)	0.0 (−0.2, 0.5)	0.0 (−0.1, 0.0)	0.0 (−0.3, 0.2)
Total indirect effect	0.0 (−0.3, 0.2)	−0.8 (−3.0, 1.5)	0.0 (−0.2, 0.1)	−0.4 (−1.7, 0.8)

[f] All models included the three potential mediators listed above as continuous variables. Adjusted models also include age, gender, race, mother's education, childhood verbal IQ at age 7, childhood chronic disease, childhood socioeconomic status, years of schooling and degree attainment. Bias corrected bootstrapped confidence intervals adjusted for clustering by household, corrected for median bias and skewness based on 5000 resamples.

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Table 4

Odds ratio (95% CL) of being in a higher blood pressure risk category

		Systolic Blood Pressure				*Diastolic Blood Pressure*			
	n	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**
Years of schooling	**531**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.0)**	**1.0 (0.8, 1.0)**	**1.0 (1.0, 1.1)**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.0)**	**1.0 (1.0, 1.1)**
Degree attainment									
Less than HS	45	0.8 (0.4, 1.7)	0.8 (0.4, 1.9)	0.5 (0.1, 1.5)	0.6 (0.2, 2.0)	1.2 (0.6, 2.4)	1.4 (0.7, 2.8)	1.0 (0.9, 1.0)	1.1 (0.4, 2.9)
HS degree/GED	150	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Certificate	123	1.1 (0.6, 1.7)	1.0 (0.6, 1.6)	1.0 (0.6, 1.9)	1.0 (0.5, 1.8)	1.2 (0.7, 2.0)	1.2 (0.7, 2.0)	0.8 (0.3, 2.1)	1.2 (0.7, 2.2)
Associate’s	95	0.7 (0.4, 1.1)	0.8 (0.5, 1.4)	0.8 (0.4, 1.5)	0.7 (0.4, 1.4)	0.6 (0.3, 1.1)	0.8 (0.4, 1.4)	1.3 (0.7, 2.3)	0.7 (0.4, 1.4)
Bachelor’s	104	0.7 (0.4, 1.1)	0.7 (0.4, 1.1)	0.7 (0.4, 1.2)	0.6 (0.3, 1.1)	0.8 (0.5, 1.3)	0.8 (0.5, 1.3)	0.8 (0.4, 1.5)	0.7 (0.4, 1.3)
Graduate	35	0.3 (0.1, 0.7)	0.3 (0.1, 0.8)	0.2 (0.1, 0.6)	0.1 (0.0, 0.5)	0.3 (0.1, 0.7)	0.3 (0.1, 0.7)	0.2 (0.1, 0.7)	0.2 (0.1, 0.6)

[b] Model 1: Unadjusted

[c] Model 2: Adjusted for age, gender and race

[d] Model 3: Adjusted for age, gender, race, mother’s education, childhood verbal IQ, childhood health and childhood SES

[e] Model 4: Adjusted for age, gender, race, mother’s education, childhood verbal IQ, childhood health, childhood SES, years of schooling and degree attainment

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Appendix C:

Association of years of schooling and degree attainment with blood pressure from linear regression models (95% CL) stratified by verbal IQ at age 7

	Systolic Blood Pressure				*Diastolic Blood Pressure*			
	<Median IQ		*≥ Median IQ*		*<Median IQ*		*≥ Median IQ*	
	Unadjusted	**Adjusted[g]**	**Unadjusted**	**Adjusted[g]**	**Unadjusted**	**Adjusted[g]**	**Unadjusted**	**Adjusted[g]**
Years of schooling	**−0.3 (−0.9, −0.2)**	**0.12 (−0.6, 0.8)**	**−0.6 (−0.9, −0.2)**	**−0.3 (−0.9, −0.3)**	**−0.2 (−0.6, 0.2)**	**0.1 (−0.4, 0.5)**	**−0.4 (−0.7, −0.1)**	**0.0 (−0.4, 0.3)**
Degree attainment								
Less than HS	−1.5 (−8.1, 5.1)	−4.4 (−13.3, 4.5)	0.6 (−7.4, 8.7)	2.7 (−5.7, 11.0)	0.5 (−4.6, 5.5)	−3.1 (−10.2, 3.9)	2.4 (−4.0, 8.7)	8.3 (2.6, 13.9)
HS degree/GED	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Certificate	2.3 (−3.8, 8.4)	1.1 (−6.6, 8.8)	−0.7 (−7.1, 5.7)	−1.1 (−8.2, 6.0)	1.9 (−2.1, 5.9)	0.5 (−4.6, 5.5)	−1.5 (−6.2, 3.2)	−1.6 (−6.4, 3.3)
Associate’s	−5.6 (−11.2, −0.1)	−4.2 (−10.8, 2.4)	−4.7 (−10.8, 1.5)	−2.9 (−10.2, 4.4)	−2.7 (−6.5, 1.0)	−1.8 (−6.3, 2.8)	−2.8 (−7.2, 1.5)	−1.5 (−6.4, 3.3)
Bachelor’s	−6.2 (−12.3, 0.0)	−8.1 (−15.8, −0.4)	−3.7 (−9.1, 1.7)	−1.3 (−8.2, 5.7)	−3.0 (−7.1, 1.1)	−4.6 (−9.6, 0.4)	−3.3 (−7.1, 0.6)	−2.9 (−7.7, 2.0)
Graduate	−8.9 (−17.2, −0.6)	−12.1 (−23.2, −1.0)	−10.1 (−16.3, −3.9)	−7.6 (−16.0, 0.8)	−4.2 (−13.2, 4.7)	−7.2 (−16.6, 2.2)	−6.6 (−11.2, −2.0)	−7.1 (−13.3, −0.9)

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Appendix E:

Odds ratio (95% CL) of being in a higher blood pressure risk category

		Systolic Blood Pressure				Diastolic Blood Pressure			
	n	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**	**Model 1[b]**	**Model 2[c]**	**Model 3[d]**	**Model 4[e]**
Years of schooling	**477**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.1)**	**1.0 (1.0, 1.1)**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.0)**	**1.0 (0.9, 1.1)**	**1.0 (1.0, 1.1)**
Degree attainment									
Less than HS	42	0.7 (0.3, 1.5)	0.7 (0.3, 1.7)	0.3 (0.1, 1.2)	0.4 (0.1, 1.8)	1.3 (0.6, 2.6)	1.4 (0.7, 3.1)	0.8 (0.3, 2.4)	1.1 (0.4, 3.5)
HS degree/GED	133	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Certificate	108	1.0 (0.6, 1.7)	0.9 (0.5, 1.7)	0.9 (0.5, 1.8)	0.8 (0.4, 1.7)	1.2 (0.7, 2.0)	1.2 (0.7, 2.1)	1.2 (0.6, 2.2)	1.0 (0.5, 2.0)
Associate's	88	0.6 (0.3, 1.1)	0.8 (0.4, 1.4)	0.7 (0.3, 1.4)	0.6 (0.3, 1.3)	0.6 (0.4, 1.2)	0.8 (0.5, 1.5)	0.8 (0.4, 1.6)	0.7 (0.4, 1.4)
Bachelor's	92	0.6 (0.3, 1.1)	0.6 (0.4, 1.1)	0.6 (0.3, 1.1)	0.5 (0.2, 1.0)	0.8 (0.4, 1.4)	0.8 (0.5, 1.4)	0.8 (0.4, 1.5)	0.6 (0.3, 1.2)
Graduate	34	0.3 (0.1, 0.8)	0.3 (0.1, 0.9)	0.2 (0.1, 0.6)	0.1 (0.0, 0.5)	0.3 (0.1, 0.9)	0.3 (0.1, 0.9)	0.2 (0.1, 0.8)	0.2 (0.0, 0.6)