Published in final edited form as:

Sociol Q. 2010 ; 51(1): . doi:10.1111/j.1533-8525.2009.01164.x.

GENDER AND THE HEALTH BENEFITS OF EDUCATION

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Abstract

Does education improve health more for one sex than the other? We develop a theory of *resource substitution* which implies that education improves health more for women than men. Data from a 1995 survey of U.S. adults with follow-ups in 1998 and 2001 support the hypothesis. Physical impairment decreases more for women than for men as the level of education increases. The gender gap in impairment essentially disappears among people with a college degree. Latent growth SEM vectors also show that among the college educated, men's and women's life course patterns of physical impairment do not differ significantly.

The positive association between education and health is well established, but whether the strength of the association depends on gender is not. Does education improve health more for one sex than for the other? We formulate and test a theory of *resource substitution* which implies that education's beneficial effect is greater for women than for men. When resources substitute for each other, the presence of one makes the absence of another less harmful. Conversely, the less there is of one resource, the more important another will be. Education may improve women's health more than men's because women have fewer socioeconomic resources such as power, authority, and earnings. We contrast resource substitution with an alternative view, which implies greater health benefits from education for men than for women. By one definition, advantaged status exists when resources yield larger benefits for members of the advantaged group. Their resources multiply to perpetuate and reinforce their advantage, so men benefit more from education than do women.

Education is a "fundamental cause" of good health (Link and Phelan 1995). Education increases physical functioning and subjective health and decreases the age-specific rates of morbidity, disability, and mortality (Leigh 1983; Doornbos and Kromhout 1990; Williams 1990; Winkleby et al. 1992; Pappas et al. 1993; Kunst and Mackenbach 1994; Ross and Wu 1995, 1996; Sorlie, Backlund, and Keller 1995; Elo and Preston 1996; Mirowsky and Hu 1996; Mirowsky and Ross 1998, 2003; Reynolds and Ross 1998; Wray et al. 1998; Rogers, Hummer, and Nam 1999; Ross and Mirowsky 1999, 2000; Beckett 2000; Crimmins and Saito 2001; Lauderdale 2001; Lynch 2003; Schnittker 2004; Singh-Manoux, Ferrie, and Marmot 2004). Still unanswered, however, is the question of who benefits most from education—the advantaged or disadvantaged?

EDUCATION, HUMAN CAPITAL, AND HEALTH

Educational attainment indicates human capital—the productive capacity developed, embodied, and stocked in human beings themselves (Becker 1964). Social and behavioral scientists often view educational attainment as one of several interchangeable measures of socioeconomic status. However, education differs from income and work in ways that may

make it especially relevant to health. Earnings and household income are monetary benefits. Work is physical or mental effort or activity (paid or not) directed toward the production or accomplishment of something. Education precedes and influences employment, work, earnings, and income, acting as a key to position in the stratification system. The resulting freedom from poverty and economic hardship may protect health. However, the consequences of formal education that improve health may go well beyond the socioeconomic. Years of education represent the accumulated knowledge, skills, values, and behaviors learned at school that help people succeed. The things learned at school that aid status attainment also may prove effective in pursuing fundamental ends that include good health (Mirowsky and Ross 2005).

In school, people learn to read, write, analyze, communicate, negotiate, solve problems, look things up, figure things out, plan, persevere, trust others, work with colleagues, and develop ideas (Kingston et al. 2003). Formal education develops skills and abilities of general value, called human capital (Becker 1964). An individual who acquires an education can use it to solve a wide range of problems because schooling builds skills, abilities, and resources on several levels of generality. On the most general level education teaches people to learn (Hyman, Wright, and Reed 1976). It develops the ability to write, communicate, solve problems, analyze data, develop ideas, and implement plans. It develops broadly useful analytic skills such as mathematics, logic, and, on a more basic level, observing, experimenting, summarizing, synthesizing, interpreting, classifying, and so on. In school, one encounters and solves problems that are progressively more difficult, complex, and subtle. The more years of schooling, the greater the cognitive development, characterized by flexible, rational, complex strategies of thinking (Spaeth 1976). Higher education teaches people to think logically and rationally, to see many sides of an issue, and to analyze problems and solve them (Nunn, Crockett, and Williams 1978; Pascarella and Terenzini 1991; Farkas et al. 1997; Kingston et al. 2003).

Education also develops broadly effective habits and attitudes such as dependability, judgment, motivation, effort, trust, and confidence (Kohn and Slomczynski 1993). Apart from the value of the skills and abilities learned in school, the process of learning builds the confidence, motivation, and self-assurance needed to *attempt* to solve problems. Education instills the habit of meeting problems with attention, thought, action, and perseverance. Thus, education increases effort which, like ability, is a fundamental component of problem solving (Wheaton 1980).

RESOURCE SUBSTITUTION

Resource substitution exists when having multiple resources makes outcomes less dependent on the presence of any specific resource. Resources can substitute for one another to improve health: One can fill the gap if the other is absent, so each has less of an effect if the other is present (Ross and Mirowsky 1989, 2006; Mirowsky, Ross, and Reynolds 2000). As a consequence, the effect of having a specific resource is greater for those who have fewer alternative resources. In this view, education is a special resource, because it indicates resourcefulness, or the general ability to meet situations effectively. Education indicates learned effectiveness (Mirowsky and Ross 2005). As human capital, education shapes the ability to create resources and to turn existing things into resources. Education is a resource that inheres in the person, rather than being external to the person like one's job or income. Resource substitution implies that education's influence on health is greater for persons with fewer alternative resources than it is for the more advantaged.

Women's disadvantaged ascribed status means that they generally have fewer resources than men.¹ Compared with men, women face more economic dependency, restricted

opportunities for paid employment, routine, poorly paid, and unfulfilling work, and less authority at work (Reskin and Padavic 1994). Women may therefore depend more heavily on education for health, and there is some evidence to suggest that education's association with physical health, heart disease, depression, and survival is larger for women than for men (Ostrove and Adler 1998; Reynolds and Ross 1998; Thurston et al. 2005; Ross and Mirowsky 2006; Zajacova 2006), although Matthews, Manor, and Power (1999) found no consistent gender differences in the effects of education on various health measures such as asthma, respiratory problems, obesity, or self-rated health.

When resources substitute, disadvantages multiply. People with the most resources are less dependent on any one of them for their health. More resources, alternatives, choices, and options make any one resource less critical. People with the fewest resources are most dependent on any one resource for their health. The absence of alternative resources means women are especially dependent on education: Women with low levels of education will suffer more impairment than will men for the very reason that they have fewer alternative resources to call on.

$H_{\text{resource substitution}}$: Education has a larger effect on levels and changes in women's health than it does on men's.

Reinforcement of Advantage

In contrast to the resource substitution perspective, the "reinforcement of advantage" perspective suggests that the influence of education on health is greater for persons with more resources. In this view, advantaged groups gain most from the resources they have, so that their resources multiply to reinforce their advantage (also called "resource multiplication") (Ross and Mirowsky 2006). One definition of a disadvantaged status is that returns to resources are smaller among the disadvantaged group and larger among the advantaged group. This theory predicts that men gain more from education than do women.

Women may get fewer health benefits from education because of lower economic payoffs. Compared with well-educated men, well-educated women have less authority and autonomy, and lower earnings. Women get lower "returns to human capital," meaning that the average increase in earnings associated with an additional year of education is smaller for women than for men (Terrell 1992; Kilbourne et al. 1994).

The "reproduction of inequality" view of education is one example of the perspective we call "reinforcement of advantage." In this view, education supposedly promotes the advantaged while holding back the disadvantaged (Aronowitz and Giroux 1993; Davies 1995). Disadvantaged groups such as people from low status backgrounds, minorities, and women receive fewer benefits from education because the role of education is to maintain the status quo.

The reproduction of inequality perspective portrays the educational system as selectively benefiting and promoting individuals with advantaged statuses, while generally discouraging and oppressing the disadvantaged. According to this view, the educational system reinforces status-appropriate behaviors and expectations, thus helping to reproduce, rationalize, and reinforce social inequality. The educational system promotes and encourages men to take lucrative or powerful positions while blocking and discouraging women. If so, then the

¹We define a resource as something that helps one achieve goals, and a disadvantaged status as one with fewer resources overall. A disadvantaged group has less power, that is less of an ability to achieve goals. Although women may have more of some kinds of resources, like social support, overall, women have fewer socioeconomic resources than men.

combination of frustrated effort and poorer outcomes also may reduce the health benefits of education for women compared with men.

$H_{\text{reinforcement of advantage}}$: Education has smaller effect on levels and changes in women's health than it does on men's.

SUMMARY AND OBJECTIVES

Resource substitution models hypothesize that education reduces physical impairment more for the disadvantaged group. They take the basic general form:

$$\text{Physical Impairment} = b_0 - b_1 (\text{education}) + b_2 (\text{disadvantaged status}) - b_3 (\text{education} \times \text{disadvantage})$$

Alternatively, *reinforcement of advantage* models hypothesize that education reduces physical impairment less for the disadvantaged group, and they take the general form:

$$\text{Physical Impairment} = b_0 - b_1 (\text{education}) + b_2 (\text{disadvantaged status}) + b_3 (\text{education} \times \text{disadvantage})$$

In sum, resource substitution and the reinforcement of advantage hypothesize opposite signs for the interaction term between education and female gender at baseline. They also hypothesize that changes in physical impairment with age depend on gender and education, which can be thought of as a three-way interaction between education, gender, and age. Resource substitution hypothesizes that the age-specific levels of physical impairment and rates of change in physical impairment are more favorable to the better educated among women than among men. Reinforcement of advantage models hypothesize the opposite; that levels and changes are less favorable to women.

SAMPLE

Our analyses use the 1995 survey of Aging, Status, and the Sense of Control (ASOC), with follow-up interviews in 1998 and 2001. It is a national telephone probability sample of U.S. households. Respondents were selected using a prescreened random-digit dialing method that decreases the probability of contacting a business or nonworking number and decreases standard errors compared with the standard Mitofsky–Waksberg method while producing a sample with the same demographic profile (Lund and Wright 1994). The ASOC survey has two subsamples, designed to produce an 80 percent oversample of persons aged 60 or older. The survey was limited to English-speaking adults. The main sample draws from all households; the over-sample draws only from households with one or more seniors. In the main sample, the adult (18 or older) with the most recent birthday was selected as respondent, and in the oversample, the senior (60 or older) with the most recent birthday was selected. Up to 10 callbacks were made to select and contact a respondent, and up to 10 callbacks were made to complete the interview once contact was made. Interviews were completed with 71.6 percent of contacted and eligible persons: 73.0 percent for the main sample and 67.3 percent for the oversample. The final sample has 2,592 respondents ranging in age from 18 to 95 at baseline. The ASOC survey has three waves of interviews taken at three-year intervals, in 1995, 1998, and 2001. Follow-up information is available for 62.3 percent of the initial sample in either wave 2 or 3. The vector analyses adjust for attrition using full information partition maximum likelihood estimation (FIML), which uses all cases regardless of their follow-up status (Wothke 2000; Mirowsky and Kim 2007).²

The following weighted statistics compare the demographic characteristics of the ASOC sample with those for the U.S. population as a whole (U.S. Bureau of the Census 1995). For ASOC and the U.S. population, respectively, the percent female is 56.2 and 51.2, the percent white is 85.1 and 82.9, the percent married is 55.7 and 55, and the mean household size is

2.67 and 2.59. For persons aged 25 or older, the percent with a high school degree is 85.1 and 80.9, and the percent with a college degree is 25.6 and 22.2. The mean household income is \$43,949 and \$41,285.

MEASUREMENT

Health is measured as physical impairment. We assess physical mobility and functioning in daily activities, using an index of seven items similar to Nagi's (1976) disability scale. Respondents were asked "How much difficulty do you have (1) climbing stairs; (2) kneeling or stooping; (3) lifting or carrying objects less than 10 pounds, like a bag of groceries; (4) preparing meals, cleaning house or doing other household work; (5) shopping or getting around town," (6) seeing, even with glasses; and (7) hearing (for those with a hearing aid, "hearing, even with your hearing aid")?" The response categories are "no difficulty" (coded 0), "some difficulty" (coded 1), and "a great deal of difficulty" (coded 2). Averaging the items produces an index with an alpha reliability of .84. Low scores indicate unimpaired physical functioning and high scores indicate impairment.³ Because it is skewed, the physical impairment scale is logged (after adding .07 to 0).

Gender compares females (1) with males (0).

Education is scored in number of years completed. The latent growth aging vector model specifies a multipopulation model: high school degree or less and some college or more by sex.

Age is scored in number of years. The latent growth aging vector analysis includes age, age³, and age² to specify the best functional form. Marital status contrasts married persons (1) with nonmarried (0). Race contrasts whites (1) and nonwhites (0).

Employment status is coded 1 for persons who are employed; 0 otherwise. *Household income* is assessed using a set of questions that maximize responses while conserving precision (Ross and Reynolds 1996). The interviewer first asks for the exact income for all members of the household from all sources. If the respondent does not report an exact household income, then the interviewer probes for approximate income ("Can you tell me, is it more than X or less than X?"). Annual household income equals the exact dollar amount if reported, and the categorical approximation otherwise. Household incomes range from \$600 to \$800,000.

Table 1 shows the means and standard deviations of all variables for men and women. Compared with men, women have significantly higher levels of physical impairment, and lower levels of education, income, and paid employment.

ANALYSES

An OLS regression model specifies the relationship of physical impairment to education and sex at baseline, testing the hypothesized interaction. The model includes education and sex,

²Models are estimated using partitioned full information maximum likelihood (FIML) estimation that maximizes the casewise likelihood (Wothke 2000), as implemented in the AMOS structural equation modeling program. FIML procedures use the full sample, partitioned into subpopulations defined by patterns of missing data. The method corrects for data "Missing at Random" or MAR, assuming multivariate normality. It assumes that the absence of values depends on a combination of random chance and tendencies predictable from the observed values. Dropouts are missing information on physical impairment at time 2 or 3. The FIML estimates are robust to the extent that the observed baseline values predict either the follow-up outcome or the tendency to drop out. The model includes baseline measures of education, income, gender, and age, known to influence attrition (Mirowsky and Reynolds 2000), strengthening the robustness.

³An index that combines physical functioning and self-reported health shows the same substantive results, as does an index of musculoskeletal impairment which removes vision and hearing from the physical impairment index.

with adjustment for age, race, and marital status. It also includes the sex-by-education product term to see if the effect of education on impairment is significantly different for men and women and if the sign of the coefficient is negative or positive. Finally, it adds employment status and household income and any significant interactions of each with gender to see if education's association with health for men and women is due solely or mostly to employment and income. The hypotheses tested with the baseline regression model refer to the effects of education on physical impairment accumulated throughout adulthood, not to the changes in impairment over a six-year period. The analysis predicts individual differences in levels of impairment which can be thought of as the aggregated sum of previous changes, rather than fluctuations in impairment within individuals over time. It provides the basic test of the hypothesized interaction.

The second analysis, an *aging vector latent growth* model, predicts the changes in physical impairment, as well as levels of it, by age, sex, and level of education. An aging vector represents the origin and change in an outcome for each birth cohort as an arrow of change from the value predicted at baseline age to the one predicted at follow-up age as the cohort transits a segment of the life course (Mirowsky and Kim 2007). The set of vectors represents the pattern of level and change in the outcome across the life course. The aging vector model provides tests of three related hypotheses about the age-specific levels of and changes in impairment across adulthood: the impairment vectors differ across levels of education, the extent of those differences depends on sex, and thus the vectors of women and men converge (or diverge) at higher levels of education. The vector analyses divide the sample into four groups: high school degree or less and some college or more by sex. A multipopulation, multiple-indicator latent growth structural equation model predicts the origin (intercept) and change (slope) with respect to time elapsed over the follow-up period (Mirowsky and Kim 2007). The model is shown in Figure 1 and described in Appendix A. Hypotheses are tested by setting (or freeing) equality constraints across the four education-by-sex groups and measuring the increment (or decrement) to χ^2 error of the overall fit as detailed below.

RESULTS

The Interaction of Education and Sex

The means and regression show a significant interaction of education and sex in their estimated effects on levels of physical impairment that support resource substitution. Circles and squares in Figure 2 plot the mean levels of impairment by sex and education, and the lines plot the predicted values based on the regression in Table 2. The coefficient of the sex-by-education interaction term is negative and statistically significant indicating that education's negative association with physical impairment is greater for women than for men.

The difference in physical functioning between women and men becomes insignificant at high levels of education. Because education is centered on its mean, the coefficient associated with sex in Table 2 represents the predicted sex difference at the mean level of education. At the mean level of education, women have significantly higher levels of physical impairment than men do. The gender gap in impairment becomes statistically insignificant at the college degree level. Women with a high school degree or less have much higher levels of physical impairment levels than men do. Among persons with a college degree, the gender gap in impairment is near zero. Higher education is associated with less physical impairment for both sexes, while also narrowing or even eliminating the gap between men and women.

Education's conditional association with health is not solely because of employment status and income. Model 2 adds employment and income to the three analyses in Table 2. Both employment and income are significantly associated with lower levels of impairment, but in no case do they "explain" the association between education and health or the conditional association estimated by the interaction, which continues to show that education's association with health is significantly greater for women than for men. Interactions of gender with employment status and with household income were not significant in any case. We find that education improves women's health more than men's, but that employment and income are equally beneficial to men's and women's health, and, furthermore that they do not account for the greater benefits of education to health for women than for men.

Life Course Vectors of Physical Impairment

The aging-vector models show that adulthood physical impairment vectors differ by sex and level of education in a manner consistent with resource substitution. Figures 3 and 4 show two views of the age vectors predicted by the results in Table 3. These graphs show exponentiated predicted values of impairment because physical impairment was logged for the latent growth structural equation model. Physical impairment increases with age, but physical impairment is lower at all ages and increases less with age for the well educated than for the poorly educated. Furthermore, the impairment gap between the well educated and the poorly educated is greater for women than for men. The patterns show increasing overlap between male and female aging vectors at higher levels of education.

Figure 3 shows education's effect on impairment over the life course of men and women. At every age, impairment levels are higher for the poorly educated than the well educated, and their impairment increases more over time. This is more true for women than for men. The left panel of Figure 3 shows that women with a high school degree or less start every age with higher levels of impairment than their well-educated counterparts, and their impairment increases much more over a six-year period. Their aging vectors of impairment never overlap. The right panel of Figure 3 shows that the gap between well-educated and poorly educated men—although still favoring the well educated—is smaller, especially among younger men. Poorly educated women are the most disadvantaged in terms of their aging vectors of impairment.

Figure 4 shows another perspective on the same results. Perhaps most interesting is the right panel, which shows that among people who have been to college, men's and women's life course patterns of physical impairment are very similar. Significance tests of constraints imposed on the model confirm that men's and women's aging vectors are not significantly different (see Appendix B). Among people who have been to college, women have almost equally low impairment levels and changes as men, especially in younger age groups. Among people with a high school degree or less, women start every age with worse impairment levels than men, and women's impairment increases much more with age, as shown in the left panel of Figure 4. Appendix B shows that men's and women's aging vectors are significantly different for people who have a high school degree or less.

DISCUSSION

Resource Substitution and Human Capital

Sociologists studying social differences in health and economists studying international development emphasize the importance of education to health and well-being within nations and between them (Sen 1993, 1997, 1999; Mirowsky and Ross 1998, 2003, 2005). Both groups argue for a second and broader revival of Adam Smith's concept of human capital. In *The Wealth of Nations* (1776), Adam Smith promoted education's role in productivity,

saying the skill of educated men is comparable in value to that of expensive machines. Sen calls the broader view of human capital “human capability” and Mirowsky and Ross call it “learned effectiveness.”

Economists of the 1960s promoted the first revival of the concept of human capital (Schultz 1962; Becker 1964). Economic theories and models had long viewed capital as material wealth in the form of money or property that is or can be used to produce more material wealth. Economists in the sixties noted that the growth of wealth in the United States and other nations exceeded what could be attributed solely to accumulating monetary and physical capital. They reintroduced Adam Smith’s concept of human capital as productive capacity developed, embodied and stored in humans themselves. Levels of formal education act as the most important measure of human capital.

More recently, the sociologists and economists arguing for a second and broader revival of Smith’s concept stress two points. First, human capital is inalienable. Knowledge and ability cannot be taken away from those who have it. Because of this, rising human capital promotes freedom as well as wealth. Second, the same knowledge and ability that enhances material productivity often discovers other means toward fundamental human ends.

If education makes a person more efficient in commodity production, then this is clearly an enhancement of human capital. This can add to the value of production in the economy and also to the income of the person who has been educated. But even with the same level of income, a person may benefit from education—in reading, communicating, arguing, in being able to choose in a more informed way ... and so on. The benefits of education, thus, exceed its role as human capital in commodity production. (Sen 1997:1959)

Sen contrasts the first revival’s focus “on the agency of human beings—through skill and knowledge as well as effort—in augmenting production possibilities,” with the second revival’s focus “on the ability of human beings to lead lives they have reason to value and to enhance the substantive choices they have” (Sen 1997:1959). Sen quotes Aristotle’s *Nicomachean Ethics*, “wealth is evidently not the good we are seeking; for it is merely useful and for the sake of something else” (1999:14). That “something else” for most and perhaps all individuals includes health.

If education develops the ability to realize fundamental human values through various means, as the theory says it will, then the more that members of a group are blocked from the socioeconomic means toward health, the more important education becomes to their health. Disparities in health associated with disadvantaged status diminish at higher levels of education. This research supports that idea.

Our results show interactions between sex and education in their effects on physical impairment that indicate resource substitution. Education reduces physical impairment for both men and women, but more so for women. Likewise, the aging vectors of physical impairment depend more on education for women than for men. As a result, the sex differences in impairment and in aging vectors of impairment become insignificant among persons who have been to college. Women have higher average levels of physical impairment overall, but the gender gap diminishes as education levels increase, vanishing entirely at the college degree level. High levels of education reduce physical impairment for both men and women while also closing the gap between them.

Education is inalienable. The ability to learn, be persistent, communicate, search out information and use it, plan, or figure out the cause of a problem and solve it are things that nobody can take away. Education puts control in the hands of people themselves. In

contrast, power brokers and gatekeepers control and distribute external rewards, such as jobs and income (Reskin 1988). People in power can control access to educational opportunities and they can regulate and distribute the socioeconomic rewards that accrue from education, but once a person has an education, no one can take away the human capital. This may make it especially important to the well-being of people who are otherwise socioeconomically disadvantaged.

Future Studies of Resource Substitution

If education builds a general ability to discover means toward ends, then the pattern observed for gender differences in the effect of education on physical impairment should apply to other types of emotional and physical health and other socioeconomic disadvantages. This research only looks at one disadvantaged status, female gender, and one health outcome, physical impairment. Future research should continue exploring education's effect on other types of well-being—like depression, anxiety, chronic conditions, and mortality—as moderated by other kinds of socioeconomic disadvantage—like poverty, recent immigration, ethnic minority status, low parental education and income, and neighborhood disadvantage. The theory of education as learned effectiveness implies that it generally will moderate or even eliminate undesirable consequences of disadvantage. We hope that research will develop a body of findings that shows how broadly the results of these analyses generalize, catalog the specific outcomes and disadvantaged statuses to which they apply, and specify the conditions under which they do or do not apply.

Two instances related to mortality suggest themselves as cases where resource substitution may require modification—gender and recent immigration. First, despite recent immigrants' and women's disadvantaged socioeconomic status, they live longer than the native-born and men, respectively. Social conditions of disadvantage that do not translate into disadvantaged health and survival outcomes are paradoxical in themselves and may dictate a modification of resource substitution theory.

CONCLUSION

Education reduces physical impairment more for women than for men at any given time and over the life course. This has positive implications for well-educated women, but negative ones for poorly educated women. Women who are poorly educated are much worse off than poorly educated men. Women with a high school degree or less have significantly higher levels of physical impairment than their male counterparts at any one time (see Figure 2) and over the whole adult life course (see the left panel of Figure 4). When resources substitute, disadvantages multiply. On the positive side, the gender gap in impairment and poor health becomes insignificant among persons with college degrees or higher. Women with a college degree share the same high levels of physical functioning as college-educated men. Since women now earn the majority of college degrees in the United States, our results suggest that the gender gap in physical health could attenuate or perhaps even vanish in future generations.

Acknowledgments

This research was funded by grants from the National Institute on Aging: "Aging, Status, and the Sense of Control" (RO1-AG12393) (Mirowsky, p.i.), and "Education, Resource Substitution, and Health" (RO1-AG023380) (Ross, p.i.), and from the National Institute of Child Health and Human Development: "Educational Differences in U.S. Adult Mortality" (RO1-HD053696) (Robert Hummer, p.i.).

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Appendix A

AGING VECTOR MODEL

The vector model has fixed effects that are functions of age at time zero and random effects that are linear functions of follow-up time. Equation 1 describes the within-person equation, in which the outcome Y for person i at time t is a linear function of time plus an error term e_{it} that is random with respect to time:

$$Y_{it} = a_{i0} + a_{i1}t + e_{it} \quad (1)$$

Equations 2 and 3 describe the between-persons equations. The within-person coefficients a_{i0} and a_{i1} of Equation 1 are functions of age at time zero (A_{i0}) centered on a reference age (45) (and divided by 100 to avoid coefficients with many decimal places), of race ($W = 1$ if white and 0 if nonwhite), and sex (not shown in equations to simplify) and of individual random deviations u_{i0} and u_{it} from the expected constant and change with respect to time:

$$a_{i0} = a_{00} + a_{01}[(A_{i0} - 45)/100] + a_{02}((A_{i0} - 45)/100)^2 + a_{03}W + u_{i0} \quad (2)$$

$$a_{i1} = a_{10} + a_{11}[(A_{i0} - 45)/100] + a_{13}W + u_{it} \quad (3)$$

Appendix B

TEST OF EQUAL VECTORS FOR MEN AND WOMEN WITHIN CATEGORIES OF EDUCATION

Testing equality of origin and slope coefficients across sex within two categories of education.

Some College or More

No equality constraints:

$$\chi^2=28.402, df=32, p=.649$$

All regression coefficients set equal for men and women with some college or more:

$$\chi^2=36.434, df=36, p=.649$$

$$\Delta\chi^2=8.032, \Delta df=4, p=.180$$

No significant difference in vectors of men and women with some college or more.

High School or Less

Revised base model frees same parameters in both populations. No equality constraints:

$$\chi^2=31.561, df=32, p=.489$$

All regression coefficients set equal for men and women with high school degree or less

$$\chi^2=56.618, df=38, p=.026$$

$$\Delta\chi^2=25.057, \Delta df=6, p=.0002$$

Significant difference in vectors between men and women with a high school degree or less.

FIGURE 1. Multipopulation, Multiple-Indicator Latent Growth Structural Equation Model Predicts the Origin (Intercept) and Change (Slope) with Respect to Time over the Six-Year Follow-Up. The Four Populations Compare Men and Women with High and Low Educational Attainment.

FIGURE 2.
Mean and Predicted Levels of Physical Impairment by Sex and Education.

FIGURE 3.
Predicted Origin and Change in Physical Impairment by Age and Level of Education for Men and Women.

FIGURE 4.
Predicted Origin and Change in Physical Impairment by Age and Gender for People with High and Low Levels of Education.

TABLE 1

Means and Standard Deviations for Men and Women

	Males	Females
Education *	13.57 (2.75)	13.05 (2.71)
Age *	50.021 (18.083)	53.396 (18.924)
White	.860 (.346)	.857 (.350)
Married *	.619 (.486)	.498 (.500)
Employed *	.607 (.489)	.442 (.497)
Household income *	47.820 (52.612)	38.617 (42.617)
Physical impairment *	.208 (.295)	.295 (.372)

* Male and females significantly different $p < .05$.

TABLE 2

Physical Impairment Regressed on Education, Sex, and Their Interaction, Adjusting for Age, Race, and Marital Status (Model 1), Employment Status and Household Income (Model 2)

	Model 1	Model 2
Education	-.020 *** (.003)	-.017 *** (.003)
Sex (1 = Female)	.045 *** (.012)	.033 ** (.012)
Education × Sex	-.010 * (.004)	-.010 * (.004)
Age	.007 *** (.000)	.005 *** (.000)
Race (1 = white)	-.037 * (.018)	-.032 (.017)
Marital status (1 = married)	-.055 *** (.012)	-.046 *** (.012)
Employment status (1 = employed)		-.091 *** (.014)
Household income		-.000 *** (.000)
Constant	-.054	.071
R ²	.224	.240

* $p < .05$,

** $p < .01$,

*** $p < .001$.

All two-tailed tests.

Notes: N = 2,565. Unstandardized regression coefficients, with standard errors in parentheses Education is centered on its mean (13.27).

TABLE 3

Origin and Change in Physical Impairment (Logged) Regressed on Age by Sex and Education, Based on a Multipopulation, Multi-Indicator Structural Equation Latent Growth Model of Aging Vectors (1995, 1998, and 2001 Aging, Status, and the Sense of Control Survey)

	Origin			
	High school degree or less		Some college or more	
	Males	Females	Males	Females
(Age –18)/100				
[(Age –18)/100] ²	5.916 ^{**}	2.946 ^{***}	2.604 ^{***}	3.093 ^{***}
	(1.555)	(.226)	(.256)	(.226)
[(Age –18)/100] ³	–5.139 [*]			
	(2.426)			
Intercept	–2.230 [*]	–1.976 ^{***}	–2.345 ^{***}	–2.328 ^{***}
	(.073)	(.054)	(.045)	(.042)
R ²	.199	.210	.207	.253
Slope of change				
	High school degree or less		Some college or more	
	Males	Females	Males	Females
(Age –18)/100				
[(Age –18)/100] ²	–3.101 [*]		.138 ^{***}	.173 ^{**}
	(1.305)		(.065)	(.051)
[(Age –18)/100] ³	3.165 [*]			
	(1.255)			
Intercept	–.061 [*]	.059 ^{***}	.018	.017
	(.033)	(.008)	(.011)	(.010)
R ²	.255	.000	.057	.099

* $p < .05$,

** $p < .01$,

*** $p < .001$ (2-tailed tests).

Notes: Metric coefficients with standard errors in parentheses; Maximum likelihood estimation using FIML to correct for data missing from attrition or nonresponse; Overall fit statistics— $\chi^2 = 28.4$, $df = 32$, $p = .649$, $CFI = 1.000$, $NFI = .999$, $RMSEA = .000$.