Short Abstract for

Schooling Differentials and Health and Mortality in Denmark: To What Extent is Schooling a Marker for Background Differentials versus Affecting Directly Health and Mortality?

Authors: Jere R. Behrman, Hans-Peter Kohler, Vibeke Jensen, Dorthe Pedersen, Inge Petersen, Paul Bingley, Kaare Christensen

Schooling differentials are a major component of socioeconomic differentials. Schooling also generally is positively associated with better health/mortality outcomes. But these associations do *not* measure how much schooling causes better health/mortality outcomes. Schooling may be proxying in part for unobserved endowments including family background and genetics that have causal effects. This study's principal goals are (1) to describe associations between schooling and health/mortality and (2) to investigate causal impacts of schooling on health and mortality using data on Danish twins. These data in combination with appropriate econometric modeling promise a quantum increase in understanding of causal effects of schooling on health/mortality outcomes. Both goals will examine whether there are significant differences (a) between females and males, (b) across birth cohorts, (c) for health-related behaviors versus health/mortality outcomes, (d) for physical versus mental/psychological health, and (e) between effects of adult schooling on their own versus their children's health.

Extended Abstract for

Schooling Differentials and Health and Mortality in Denmark: To What Extent is Schooling a Marker for Background Differentials versus Affecting Directly Health and Mortality?

Authors: Jere R. Behrman, Hans-Peter Kohler, Vibeke Jensen, Dorthe Pedersen, Inge Petersen, Paul Bingley, Kaare Christensen

A. Introduction

Schooling differentials are a major component of socioeconomic differentials in most societies. Schooling also generally is positively associated with better health-related behaviors and better health/mortality outcomes. Those with more schooling tend to have better physical and mental health and to have longer lives – which is often interpreted to mean that increasing schooling improves health.[1] But these associations do *not* measure by how much schooling causes better health-related behaviors and better health/mortality outcomes. Schooling may be proxying in part for unobserved endowments including family background and genetics that have causal effects on health behaviors and health/mortality outcomes. This study's principal goals are (1) to describe the association between schooling and health/mortality for various cohorts in Denmark and (2) to investigate for the same cohorts the causal impact of schooling on health and mortality, net of endowments, using data on twins from Denmark. The twins data in combination with appropriate econometric modeling promise a quantum increase in understanding of causal effects of schooling on health-related behaviors and health/mortality outcomes, net of endowments. Both goals will examine whether there are significant differences (a) between females and males, (b) across birth cohorts, (c) for health-related behaviors versus health and mortality outcomes, (d) for physical versus mental/psychological health, and (e) between effects of adult schooling on their own health and on their children's health.

B. Data

The study relies on two sets of variables from the Danish Twins Registry:[2] (1) measures of health, health-related behaviors and mortality for the twin and his/her children and (2) measures of schooling attainment of the twin.

[1] There are many studies that consider such possibilities, some of which focus on the relative schooling (and other aspects of socioeconomic status) on health (e.g., Adams, et al. 2002; Adler, et al. 1994; Brooks-Gunn, Duncan and Maritato 1997; Case, Fertig and Paxson 2002; Case, Lubotsky and Paxson 2002; Deaton 2001a,b; Deaton and Paxson 1998, 1999; Kawachi, Kennedy and Willinson 1999; Marmot 1999; Mellor and Milyo 2002; Preston 1975; Preston and Elo 1995; Ross and Mirowsky 1999; Smith 1999; Strauss and Thomas 1998; Wilkinson 1992, 1996, 2000).

[2] This has been a valuable source of data for study of a number of biomedical, biodemographic and socioeconomic topics. For more information and some examples, see Christensen, et al. 1995, 1996, 1998, 2000; Gaist, et al. 2000; Hauge 1981; Kohler, Behrman and Skytthe 2005; Kohler, et al. 2002a, b; Kohler and Kohler 2002; Kohler and Rogers 1999, 2000; Kohler, Rogers and Christensen 1999, 2003; Kohler, Skytthe and Christensen 2001; Kyvik, et al. 1996; Skytthe, et al. 2002.

Measures of health are obtained from three sources: (a) the *Longitudinal Study of Aging in Danish Twins* (LSADT); (b) a linkage between the Danish Twin Registry and the various population-based registers at Statistics Denmark that provides rich and longitudinal information for health, income and education.

B.1 The Longitudinal Study of Aging in Danish Twins (LSADT);

The Longitudinal Study of Aging Danish Twins is a cohort-sequential study of elderly twins who were born in Denmark (Christensen et al., 1999). LSADT began in the winter of 1995 with the recruitment of all like-sex twins born in Denmark prior to 1920 and thus at least 75 years old at initial assessment. The 1995 LSADT sample was reassessed every 2 years, in 1997, 1999, and 2001, at which time new cohorts were also recruited into the study and also followed every 2 years. Twins born in 1920 through 1923 were added in 1997, when they were at least 73 years old; twins born 1924 through 1928 were added in 1999, when they were at least 70 years old; and twins born 1929 through 1930 were added in 2001, when they were at least 70 years old. Except for the 1920 through 1923 birth cohorts, new twins were added regardless of cotwin status. For the 1920 through 1923 cohorts, only twin pairs where both members were surviving were sampled.

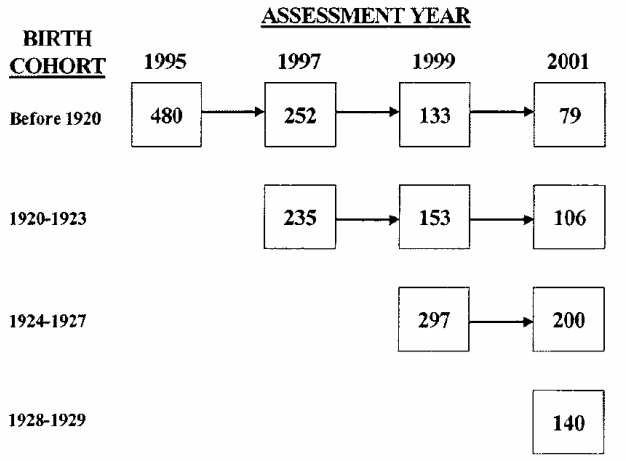

Fig. 1. Number of twin pairs participating at each wave of the Longitudinal Study of Aging Danish Twins (LSADT).

The LSADT sample is drawn from the older cohorts of the Danish Twin Registry, which includes all twins born in Denmark between 1870 and 1910 and all like-sex twins born in Denmark between 1911 and 1930 (Hauge, 1981; Holm, 1983). The residence and status of all eligible twins were obtained from the Danish Central Person Registry just prior to the time of assessment. A total of 4731 individual twins have completed an intake assessment, in person or by proxy report, in LSADT. The numbers of twins completing a second-, third-, and fourth-wave assessment are 2990, 1337, and 672, respectively. The declining number of participants at each wave reflects the cohort-sequential nature of the study (e.g., only those who started the study in 1995 could have completed a fourth wave of assessment in 2001), mortality (992 of the twins who completed an intake assessment had died by the time of the 2001 assessment), and sample dropout. Participation rates for eligible and living twins at each wave generally fall between 70% and 80%. Christensen et al. (1999) compared participants and nonparticipants in the 1995 survey and found that the two groups did not differ significantly in age or zygosity, although participants were slightly, but significantly, more likely than nonparticipants to be male and to have been hospitalized between 1977 and 1994. The number of intact twin pairs that participated at each LSADT wave is given in Fig. 1. Among the 4731 individual intake participants were 1152 intake pairs and 2427 “single” twins. The information on pysical and mental/psychological health measures that will be investigated in this study are listed in Appendix 1.

C.2. Linkage between the Danish Twin Registry and the various population-based registers

In addition to the LSADT, our analyses of the schooling differentials and health will be based on a new longitudinal dataset obtained through a linkage between between the Danish Twin Registry and the various population-based registers. This linkage provides information on education and detailed longitudinal information on income, region of residence, and health for all Danish twins born 1920--1975 that have been identified in the Danish Twin Registry. In addition to twins born 1920-1975, the linked dataset also includes children born to twins (with complete linked fertility histories for cohort born after 1945), and a 5% same-age random sample obtained from the Danish population and their children. The data encompass approximately 36,000 twin in complete pairs and 220,000 singletons born 1920-75, and 392,000 children born to twins and singletons.

The linkage between the Twin Register and the various popuation registers has been completed in the summer of 2005, and the data are currently made available for analyses on limited-access computers at Statistics Denmark in order to assure confidentiality.

The primary indicator of health in our register-based analyses for twins, the children of twins, and the random population-sample include the number of hospitalizations and the number of days in hospitial in each year duing 1980-2002. Since women are likely to have hospital stays in associated with child-birth, some of our analyses will exclude pregnancy related hospital stays.

Our measures of education include the highest vocational and academic training and the months/years of schooling associated with the highest attained degree. In addition, the register linkage will include longitudinal information on labor force participation, occupational classification and income for each year duing 1980-2002. The availability of the municipality of residence for each year duing 1980-2002 furthermore allows the inclusion of various demographic, economic and social indicators characterizing the community of residence of twins and their children in each year since 1980.

C. Methodology

Central questions that are explored in this study are: (1) what are the cross-sectional *associations* between schooling attainment and health, health-related behaviors and mortality for adults and for their children and (2) what are the estimated *causal impacts* of schooling on health-related behaviors and health and mortality outcomes adults and their children when the twin design is used to control for unobserved family endowments and to what extent do these estimated impacts differ from what cross-sectional associations suggest.

C.1 Reduced-form impact of own schooling on own health: We begin with a statistical model of the family allocation of schooling in "childhood" that incorporates endowment heterogeneity and that is consistent with theoretical models of the intrafamily allocation of resources. Consider the following linear representation of an equation relating subsequent (post-childhood) health behaviors or health/mortality outcomes H_{ij} for the ith member of family j to his or her schooling

S_{ij} and to three sets of unobserved variables representing (i) endowments h_j that are common among all children of family j, (ii) the component of endowments or "innate health" that is specific to child i in j, represented by a_{ij}, and (iii) a random health shock that is specific to i in j, inclusive of measurement errors in health, represented by v_{ij}, that is not correlated with u_{ij}:[3]

(1) $H_{ij} = \beta_S S_{ij} + h_j + a_{ij} + v_{ij},$

where β_S is the effect of schooling. S_{ij} is itself a function of unobserved variables that pertain to the family and to the individual child in the family:

(2) $S_{ij} = \alpha_a a_{ij} + \alpha_h h_j + s_j + u_{ij},$

where s_j represents the joint influence of exogenous features of the family environment in childhood, including prices, family income, parents' human capital characteristics, and local schooling options; α_h is the effect of the family-specific endowment of the child h_j on schooling investment, and u_{ij} is a disturbance that affects S_{ij} but not H_{ij} except indirectly through S_{ij}. As is well known, the parameter β_S is not identified in equations (1) and (2) if α_a or α_h is not zero. β_S is estimated with bias if equation (1) is estimated across individuals with different values of h_j and a_{ij}. The regression coefficient for a OLS estimate of relation (1) is $\text{cov}(H_{ij}, S_{ij})/\sigma^2(S_{ij}) = [\beta_S(\sigma^2(S_{ij}) + \text{cov}(S_{ij}, h_j) + \text{cov}(S_{ij}, a_{ij})]/\sigma^2(S_{ij})$, which is a biased estimate of β_S unless $\text{cov}(S_{ij}, h_j) + \text{cov}(S_{ij}, a_{ij})=0$. Thus generally the cross-sectional estimate of the association between schooling and health is a biased estimate of the causal impact of schooling on health because schooling is partially proxying for genetic, family background and other endowments in such estimates.

With no further assumptions, it is clear that neither β_S, the health impact of schooling, nor the α_a or the α_h schooling allocation parameters in childhood, are identified even if sibling-pair data are used to control in the estimation of β_S for the covariant common components of the endowment and environment h_j and s_j. This is because of the existence of the specific component of the endowments a_{ij}. As long as families or individuals respond to individual-specific differences in endowments, and such differences are important, then sibling estimators may not be very useful. In recognition of this problem, researchers (e.g., Behrman and Taubman 1976, Behrman et al., 1980; Ashenfelter and Krueger 1994, Behrman, Rosenzweig and Taubman 1994, Miller, Mulvey and Martin 1995, 1997, Ashenfelter and Rouse 1998, and others) have employed samples of pairs of MZ twins, between whom there are no endowment differences, to identify β_S in estimates of models parallel to that presented above with ln earnings as the dependent variable of interest (and in Behrman and Rosenzweig 2002, 2005 with child schooling as the dependent variable), though to our knowledge this approach has not been explored for the relation between schooling and health. Equations (1) and (2) can be rewritten for MZ twins:

(1A) $H_{ij}^M = \beta_S S_{ij}^M + h_j^M + v_{ij}^M$

[3] There are many studies that document the association of genetic endowments on physical and mental health (e.g., Amouyel, et al. 1996; Bartres-Faz, et al. 2000; Chen, et al. 2001; Christensen, et al. 1995, 1998, 2000; Clee, et al. 2001; Eicher, et al. 2002; Forsberg, et al. 2002; Frosst, et al. 1995; Humbert, et al. 1993; Jenny, et al. 2002; Jiang, et al. 2001; Kelly, et al. 2002, Kluijtmans, et al. 1996; Morita, et al. 1997; Myllykangas, et al. 2001; Pericak-Vance and Haines 1995; Sawano, et al. 2001; Voetsch, et al. 2002).

(2A) $S_{ij}^{M} = \alpha_h h_j^{M} + s_j^{M} + u_{ij}^{M}$,

where the superscript M refers to MZ twins. Relations parallel to (1A) and (2A) can be written for the kth MZ twin in the jth family. Within-MZ-twin estimators are obtained by subtracting such relations from (1A) and (2A). With a within-MZ-twin estimator, all of the unobserved endowment and the common environment components in (1A) and (2A) are swept out.

These within-MZ estimators can be used to identify the true reduced-form impact of schooling on health-related behaviors and health/mortality outcomes under the assumptions of this section for all of the own-health behavioral and outcome variables and changes in those variables in all of the data sets that are introduced in Section B. As noted, comparisons may be made with estimates of relation (1) for the same health outcomes to learn to what extent the estimates of the impact of schooling on health β_S are biased in cross-sectional estimates that are standard in most of the literature because of the failure to control for unobserved endowments h_j and a_{ij} that affect health and that are correlated with S because they in part determine schooling in relation (2). Comparisons also can be made of the within MZ estimates for females versus males and across birth cohorts to see if there are significant gender or cohort effects in the reduced form impact of schooling on health-related behaviors and health/mortality outcomes.

C.2 Reduced-form impact of parental schooling on child health: There are many studies that document associations between parental schooling (particularly mother's schooling) and child health (see survey in Strauss and Thomas 1998). However, there is a fundamental problem with the findings on intergenerational schooling "externalities" from mothers' schooling to their children's health. There may be intergenerational endowment correlations with the results that more "able" mothers may obtain more schooling and their children may have correlated health endowments. If so, the association between mother's schooling and child health may merely reflect these intergenerational endowment correlations. Moreover, even among mothers with the same abilities, those with higher levels of schooling may have children with better health due to assortative mating on endowments in addition to on schooling. (Behrman and Rosenzweig 2002 discuss these issues within an explicit mathematical model.) Therefore we will estimate relations parallel to (1) and (1A) above, but where the dependent variables are health and health-related behaviors of children of twins and the right-side variables are the adult twins' (parents') schooling. The comparison, once again, will indicate to what extent the estimated associations between child health and parental schooling from estimating relation (1) differ from the estimated causal impact of parental schooling on child health from estimating relation (2). It should be noted that these estimates are inclusive of the impact of spouses through assortative mating on schooling and on endowments.

This estimation strategy will lead, for the first time, to estimates of the impact of parental schooling on child health net of endowments that are correlated across generations. Though to our knowledge such estimates have not been made before, investigation of the impact of parental schooling on child schooling indicates that controlling for endowments that are correlated across generations and between spouses makes a substantial difference in the estimated impact of mother's schooling and, indeed, causes a sign reversal as compared with cross-sectional estimates (Behrman and Rosenzweig 2002).

C.4 Comparisons of Estimates: There are a number of comparisons that we make of estimates of the different models with different outcomes. These will be informative about:

(a) The implications of controlling for endowments in assessing the total impacts of schooling on health: We anticipate that controlling for all endowments using the within-MZ-estimators may make major differences in impact and even possibly in the signs of some of the estimated effects of schooling. If so, the standard estimates in the literature may be quite misleading. But whether this is the case for the impact of schooling on health-related behaviors and health/mortality outcomes, of course, is an empirical question – and a central question that the study is the first to answer.

(b) Whether our best estimates of these impacts differ among demographic groups: We examine whether our preferred estimated schooling impacts on health-related behaviors and health/mortality outcomes differ by demographic groups defined by gender, and birth cohort, and whether the biases if endowments are not controlled differ across these groups. As noted in Behrman and Rosenzweig (1999), these biases are not fundamental parameters, but may differ with differing market and policy environments. For instance, do impacts of schooling on health appear less for older cohorts due to earlier mortality selection as suggested in the literature (e.g., Preston and Elo 1995, Elo and Preston 1996) once there is control for endowments?

(c) Whether our estimates of the direct and indirect effects of schooling on health-related behaviors and health/morality outcomes differ by types of indicators of these behaviors and outcomes : We estimate impacts of schooling on a number of different indicators of health-related behaviors and health/mortality outcomes, which enables us to explore to what extent there are important differences in these effects across these indicators (e.g., do they differ for mental versus physical health versus self-reports of overall health?) and whether there are differences, again, in the biases if there is not control for endowments.

(d) Whether our estimates differ between the impacts on own health and on one's childrens' health: As noted, the problems with interpreting the usual cross-sections associations between schooling and health are similar for own health and for children's health. But it is an empirical question, which we explore, whether the biases are more important for one or the other.

D. An Appetizer – Some Preliminary Results

This study is well underway, but involves handing large and complicated data sets, in one case with complicated links to official registries so that access is limited to a dedicated computer in the University of Southern Denmark in order to assure confidentiality. Therefore at this time only some vary preliminary estimates using some of the LSDAT health outcomes and preliminary schooling coding for a subset of cohorts are available.

The sample for our preliminary estimates includes all complete monozygotic twin pairs who were recruited into the LSADT, resulting in 748 twins in 374 pairs (152 male pairs, 222 female

pairs). The measure of physical and mental/psychological health are obtained from the first LSADT in which a twin pair participated.

Despite their preliminary natures, the are quite provocative. The table below gives some examples. From the OLS estimates in this table the usual interpretation would be that own elementary schooling significantly increases adult cognitive skills for doing calculations and (at the 0.10 level) word comprehension and that post-elementary schooling significantly increases both of these adult cognitive skills and overall well being and significantly reduces the probability of having asthma and (at the 0.10 level) dying. Thus, schooling is significantly associated with adult mental and physical health and mortality, and the usual interpretation would be that schooling has significantly positive effects on mental and physical health and on survival.

However consider what happens if all common endowments (genetic, family background, community) are controlled by using within MZ twins estimates for the same sample as in relation (1A). The results are striking. Of the seven schooling coefficient estimates that are significantly nonzero in the OLS estimates at least at the 0.10 level (five at the 0.05 level), only one remains significantly nonzero at the 0.10 level once there is control for the endowments. Thus, the standard OLS estimates for which the standard interpretation is that schooling has significant positive effects on health are fundamentally misleading because in those estimates schooling primarily is controlling for unobserved endowments.

While these results are very preliminary and only refer to some of the variables in one of the data sets that the completed paper will have, they demonstrate some potentially very interesting results that throw into question the conventional wisdom about the protective effects of schooling on health.

Table: OLS and ΔMZ Impact of Schooling on Mental and Physical Health, Danish Twins (LSADT)

	Cognitive Skills				Asthma		Mortality		Self-Reported General Well-being	
	Words		Calculations							
	OLS	ΔMZ	OLS	ΔMZ	OLS	ΔMZ	OLS	ΔMZ	OLS	ΔMZ
Elementary	0.13	-0.10	0.12	0.19	0.16	0.24	0.09	0.11	-0.02	0.00
	(1.69)	(0.50)	(2.56)	(1.93)	(0.93)	(0.45)	(0.74)	(0.29)	(0.67)	(0.04)
Post-elementary	0.23	0.06	0.15	0.08	-0.46	-0.35	-0.20	-0.24	0.08	-0.013
	(3.25)	(0.43)	(3.39)	(1.18)	(2.41)	(1.10)	(1.72)	(1.03)	(2.84)	(0.029)

NB: Beneath point estimates are absolute t values. The OLS estimates also include a quadratic in age.

Appendix 1: LSADT Questions on Health

Question	1995	1997	1999	2001
Did a doctor ever tell you that you have/had any of the following diseases:	10	10	10	11
- Diabetes	a	a	a	a
- Osteorarthrosis	b	b	b	b
- Rheuratoid arthritis	c	c	c	c
- Osteoporisis	e	e	e	e
- Chonic bronchitis	f	f	f	f
- Asthma	h	h	h	h
- Parkinson disease	o	o	o	o
- Migraine	q	q	q	r
- Cancer, apart from skin cancer	r	r	r	s
- skin cancer			s	t
- stroke	s	s	t	
- heart attack	t	t	u	
- Arrhythmia of the heart	v	v	w	z
- Hypertension, treated with prescripiton drugs	w	w	x	aa
- other heart problems	x	x	y	bb
- Mental disorders			kk	qq
Sum of all questions 10 (or 11) a -- tt that are answered with 1 (= have now)				
Sum of all questions 10 (or 11) a -- tt that are answered with 2 (= ever had)				
selected related questions on general health	11 through 22	11 through 18	11 through 25	
- paralysis of arm/egg, log sore, amputation	11 (a -- e)	11	11	12
- bone fracture since age 40	12	12	12	13
- transitory weakness			13	14
- severe hit, lost consciouslness		13	14	15
- wheezy breathing			20	21
Self-perception and importance			62 (62.a1 -- 62a.4)	60 (60.a1-- 60.a8)
Cognitice performance				
- deduct 7 from 100	63	59	68	64
- basic object identification	65	61	70	66
- number repetition	74	69	77	73
- word recall	76	71	81	77

Current state of mind, compared to 6-12 months ago	130 through 163			
- weight gain/loss	138	145	137	133
- coping with things	139	146	138	134
- decision-making difficulties	140	147	139	135
- feeling of sadness or depression	152	159	150	146
- optimism/pessimism about future	161	168	152	148
- depression resulting in doctor visit	130 -- 131	137 -- 138	132 -- 133	128 -- 129

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