The economic value of health gains associated with education interventions.

(Draft)

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I. Introduction

Those who graduate from high school live about 9.2 years longer than high school

dropouts (Wong, Shapiro et al. 2002). Some of this increase in life expectancy can be attributed

to an improvement in cognitive ability and decision-making through education. Other factors that

improve with increased educational attainment, such as income, occupational safety, and access

to health insurance, are also associated with better health outcomes (Muennig et al 2005a;

Muennig et al 2005b). Finally, some of the association between higher educational attainment

and health may be attributable to innate intelligence, genetically-determined personality

characteristics, or even physical attractiveness (Gottfredson 2004).

The goal of this paper is to estimate effect of educational interventions on health care

costs. Because health data from randomized education trials are unavailable, the effect of

education on health and health care utilization must be estimated using cross-sectional data. It is

therefore necessary to critically examine the literature to ascertain the extent to which cross-

sectional analyses of health data can reasonably approximate changes in health care

expenditures, morbidity, and mortality.

From a review of the literature, I conclude that changes in health expenditures, morbidity,

and mortality can reasonably be captured using linear regression models and cross-sectional data.

I find that as educational attainment improves, one's health expenditures increase even as one's

health status improves, an effect that has been previously observed in a randomized controlled

trial (Newhouse & Rand Corporation. Insurance Experiment Group. 1993). Health expenditures

increase with educational attainment in part because increases in job quality and income afford

access to health care, but may also occur because people with more education are more likely to

seek out preventive care. Similarly, reductions in morbidity and increases in life expectancy may

occur as income, occupational quality, and cognitive ability rise alongside educational

attainment.

I generate linear regression models using a large nationally representative cross-sectional

dataset. I predict changes in expenditures and years of perfect health lived when students are

advanced from 11th grade to 12th grade. I similarly examine shifts in public and private insurance

utilization to estimate changes in costs in the public sector. Finally, I examine the effect of

promoting the 600,000 students who did not graduate from high school in 2004 to 1) high school

graduates, and 2) one full grade ahead (e.g., from 9th grade to 10th grade). Note that all values in

this paper, including findings of studies published in earlier years, are presented in constant 2004

dollars to assist the reader.

II. Linking education to health

In this section, I explore the extent to which cross-sectional data can reasonably be used

to predict the health effects of real world educational interventions. I first examine some of the

reasons why children exposed to an educational intervention may or may not achieve the health

status of their similarly educated peers. I then describe the causal mechanisms linking increased

educational attainment to improved health.

1. Adverse childhood circumstances and study selection bias

In addition to increasing a student's knowledge, an effective educational intervention will

increase the student's future income, occupational status, prestige, and access to social networks,

all of which generate health (Link & Phelan 1995). However, few such students may achieve the

same level of knowledge, income, occupational status, prestige, or access to social networks as

similar students from more advantaged backgrounds. Those who are born into relative affluence are not only born with many of these advantages in place, but they may also be generally exposed to a consistently higher level of educational quality than can reasonably be realized through most educational interventions.

Those born into relative affluence are also born into relative health; low-income children are more likely to have been exposed to tobacco and alcohol in utero, more likely to be exposed to toxins such as lead as a child, and more likely to be victims of trauma through adolescence (Chen et al 2002; Wilkinson 1999). Both abuse and toxic exposures have an adverse effect on cognitive development (Canfield et al 2003; De Bellis et al 1999). Low-income children are also more likely to be exposed to environmental stressors that set off a cascade of biochemical events in the body that are harmful to one's health (Brunner et al 1996). For these reasons, disadvantaged children who later achieve economic success may, to varying degrees, be more likely to die prematurely in adulthood than others in their newly acquired social class (Marmot et al 2001; Poulton et al 2002).

However, it is possible that those children that do manage to overcome poor schooling, abuse, and other harsh environmental exposures, and nonetheless respond to an educational intervention geared toward improving schooling will either be the most intellectually gifted or have been exposed to the least adverse environmental circumstances. Thus, low-income children that respond to an educational intervention may do better in life and live longer than their less educated peers. Because of this potential study selection bias, interventions targeted toward low-income groups in failing schools may therefore produce health effects that are larger than might be expected.

Linear regression analyses predict changes in total wage income with changes in educational attainment that very closely match what has been observed in a wide array of studies and study designs examining the impact of educational interventions on wage (see Rouse in this volume for a review). The effects of childhood material disadvantage and study selection bias may therefore cancel each other out. If this is true for wage income, it may well be true for health gains as well. (See the Technical Appendix for a more detailed analysis of potential confounding variables and how they were examined.)

2. Causal links between education and health

Relative to those with a high school diploma, adults that did not graduate from high school are more likely to die prematurely from cardiovascular disease (35% of all deaths), cancer (27% of all deaths), infection (9% of all deaths), injury (5% of all deaths), lung disease (5% of all deaths), and diabetes (4% of all deaths) (Wong, Shapiro et al. 2002). The underlying risk factors for all of these causes of death (with the exception of injury) are similar, and all are plausibly related to educational attainment. In addition to fitting what has long been known about behavioral risk factors and health insurance enrollment by educational attainment, the underlying risk factors are remarkably consistent with new evidence from the fields of psychology, neuroanatomy, neurophysiology, molecular biology, sociology, and epidemiology (see Figure 1).

In this figure, we see that cognitive ability, social standing, other psychological or emotional factors, behavioral risk factors, and health insurance form the core putative causal connections between educational attainment and cardiovascular disease, cancer, infection, and diabetes mellitus. Figure 2 shows some of the linkages between educational attainment and the other major causes of death, lung disease and injury.

a. Effects of improved income and occupation

Early associations between "Type A" lifestyles and heart disease led to the popular misperception that affluence and education naturally led to stressful lifestyles (Haynes et al 1978). Wealthier, more educated persons certainly have some stress in their lives. However, the stress associated with having "too many things to do" appears to be less stressful than having "too little money," "health problems," "little leisure time," a high amount of "environmental noise," and/or "problems with children" (Taylor 2002).

This stress increases the risk of heart disease, cancer, infectious disease, and diabetes mellitus by profoundly altering the body's biochemical makeup (McEwen 1998). (See Figure 1, upper right corner.) When faced with a predator, the body releases a cascade of chemicals associated with the "fight or flight" response system. These are most helpful when one is about to be attacked; they raise blood pressure, increase blood sugar to give cells energy, and release a host of chemicals that can mitigate damage if injured.

When the stress becomes chronic, however, these same chemical mediators lead to premature cell aging, DNA damage, blockages in the arteries supplying the heart and brain, and immunosuppression (McEwen 1998). For instance, certain cells show telltale signs of premature aging, with up to 10 years difference in the biological age of the cells of the least stressed relative to the most stressed subjects (Epel et al 2004; Irie et al 2001). Likewise, when randomly allocated to receive live cold virus or a placebo, subjects with higher self-rated stress ratings are more likely to become ill (Cohen 1995).

Among those with stress in their lives, having social support may help. Social networks appear to improve coping with stressful situations, reduce loneliness and isolation, and also

provide nepotistic connections that can help secure shelter or new sources of work (Cassel 1976).
Conversely, social isolation or abuse may hinder both educational attainment and health. Studies
on rodents, non-human primates, and humans all suggest that social deprivations associated with
poverty can have a profound effect on adult social pathology and self-destructive behaviors,
increasing risk of injury as in Figure 2 under the general heading of "behavioral risk factors"
(Harlow & Suomi 1971; Higley et al 1993) (Clarke & Schneider 1997; Clarke et al 1994;
Schneider et al 1992; Schneider et al 2002; Schneider et al 1999). Depression, anger, and weak
social networks also have strong associations with lower educational attainment and with the
diseases and conditions listed in Figure 1 under the heading of "psychological risk factors"
(Cohen et al 2003; Kubzansky et al 2001; Wilkinson 1999; Yan et al 2003). Clearly, these two
categories overlap, but are presented separately for simplicity.

Education might help attenuate the effects of psychosocial deprivations by improving the
environmental conditions that aggravate pathological behavior (Costello et al 2003; Kiecolt-
Glaser et al 2002). Higher levels of social support and lower levels of stress may help reduce
initiation of risky health behaviors and foster their cessation (Cassel 1976; Ross & Van Willigen
1997). However, it is highly unlikely that a quality education alone would serve as a panacea for
social pathology; individuals of dissimilar socio-economic backgrounds who have attained
similar levels of educational attainment may well have a different propensity for smoking or
engaging in criminal activity (Poulton et al 2002).

Behavioral risk factors, therefore, plausibly arise in part from the social environment.
They are also likely to arise from the physical environment. Low-income neighborhoods offer
few opportunities for eating healthfully or exercising (Morland et al 2002). In fact, the one
positive health effect among subjects randomly assigned to receive housing vouchers allowing

them to move to slightly more affluent neighborhoods was a lower rate of obesity (Kling et al 2004) To the extent that higher income removes individuals from poor neighborhoods, it also reduces their exposure to crime, poor housing conditions, and other environmental hazards (e.g. proximity to polluting industry). A better job also translates into a higher probability of having a safe work environment (reducing trauma) and health insurance (Mills 2002).

A final consideration is that educational interventions are likely to improve subjects' chances of enrollment in health insurance programs. While health insurance has never been proven to improve health, it is now widely believed that it reduces the risk of premature death from cardiovascular disease (via cholesterol lowering medications, anti-hypertensive medications, and blood sugar control in diabetics), infectious disease (via prompt treatment of life-threatening illness and the provision of anti-retroviral medications), and cancer (via early detection) (Hadley 2003). (See Figure 1, center.)

In short, by improving income and occupation, effective educational interventions may attenuate life stressors, improve social networks, reduce behavioral risk factors, and increase the likelihood of possessing health insurance. Less direct pathways exist as well. For instance, merely attending school can build nepotistic connections and confer the prestige needed to build income and self-esteem (Link & Phelan 1995). In addition to these major mechanistic connections linking lower educational attainment and poor health, education also serves as a direct link to health.

b. Direct effect of education on health

Education exerts direct effects on heath by improving cognitive ability (Adler & Ostrove 1999; Baker et al 2002; Barton et al 2003; Gottfredson 2004; Kiecolt-Glaser et al 2002;

Mechanic 2002). Cognitive ability may be directly linked to 1) health behaviors, 2) medication

compliance and comprehension of doctors' instructions, 3) one's ability to navigate complex

bureaucracies, such as health systems, 4) effective coping mechanisms for dealing with stressors,

5) the ability to navigate and meaningfully participate in social activities, and 6) improved

decision-making skills.

While behavioral risk factors may arise from social pathology and neighborhood

conditions that facilitate their adoption, improved cognition and health knowledge may mitigate

these effects. For instance, virtually everyone knows that smoking, drinking, and eating poorly

are bad for the health, but educated persons might be more likely to draw more concrete and

meaningful links between such acts and poor health than less educated persons. They may also

be more likely to cognitively process harmful messages from the industries that produce such

goods. Finally, improved cognition may lead to improved coping mechanisms, lending people

the power to resist eating poorly or smoking in times of stress (Kiecolt-Glaser et al 2002).

These direct links are not dependent on educational attainment *per se*, but rather upon the

sum total knowledge and skills acquired by the student. Thus, eight years of a challenging and

rich educational experience would likely be superior to the twelve years of education one might

attain in failing inner city school that does not allow for adequate literacy or numeracy

(Gottfredson 2004; Lichtenstein & Pedersen 1997). Genetic factors may also play a role, and are

discussed in detail in the Technical Appendix.

c. Evidence from education studies

The High Scope/Perry program randomly assigned African-American children to either

receive a high quality preschool education or no intervention (Schweinhart 2004). By age 5, 67%

of the children in the intervention group, relative to just 28% of the children in the control group, had a measured IQ greater than 90. By age 40, those in the intervention group were a third less likely to have multiple arrests and were a third more likely to have earnings over $20,000 per year. Relative to those who did not receive the intervention, males who received the intervention were nearly twice as likely to raise their own children, less likely to use drugs, and more likely to report satisfactory relationships with their children.

One non-randomized age-matched longitudinal trial and a meta-analysis of other preschool programs (including the national Head Start program) produced similar findings, though the effect sizes were not as large in most cases (Karoly & Bigelow 2005; Reynolds et al 2001). The Chicago Child-Parent Centers program found lower rates of child abuse among the children and a lower likelihood of involvement in the criminal justice system—both of which are major risk factors for trauma and indicators of social pathology (Reynolds et al 2001).

d. Expenditures and income

While little is known about the influence of educational attainment on medical expenditures, there is evidence from a randomized trial that income exerts a strong effect on health care expenditures (Newhouse & Rand Corporation. Insurance Experiment Group. 1993). Subjects were assigned various health plans ranging from a plan with premium coverage (all care provided for free) to plans that required large co-payments or deductibles on the part of the subjects. Interestingly, among those with full insurance coverage, increased family income is associated with both better health and with a higher likelihood of contact with medical providers (Newhouse & Rand Corporation. Insurance Experiment Group. 1993). (See Table 1.)

Possible explanations for this higher utilization among healthier, wealthier subjects include: 1) such subjects are better cognitively equipped to navigate health bureaucracies, 2) such subjects have less fear of institutions, and/or 3) such subjects value preventive care more (e.g., due to a lower discount rate, less fatalism, etc.). Overall, health status does exert an effect on expenditures; those who have lower income are more likely to be severely ill and thus require more intensive and expensive care (Newhouse & Rand Corporation. Insurance Experiment Group. 1993). Therefore, despite lower utilization, fully insured subjects in the lower third of income earners ran up expenses that were comparable to the upper third of income earners.

III. Predicting the effects of education on health

1. Overview and definitions

a. Boundaries of the analysis

In this analysis, I examine the effect of elevating the average high school dropout with an educational attainment of 11 years to a high school diploma via a generic educational intervention. I also examine the effect of an educational intervention that increases the educational attainment of all 600,000 non-institutionalized high school dropouts in 2004 by one year and to a full diploma. (The latter measure provides a rough idea of the total health dollars and health gains that might be realized by graduating all persons in the US.) Finally, I examine the long run cost of various real world educational interventions. While some sensitivity analyses are presented here, the Technical Appendix contains more detailed sensitivity analyses.

I employed the societal perspective and a public (governmental) perspective. I used a discount rate of 3.5% in the base case analysis, and tested this over a range of 0% to 8% in a sensitivity analysis. I measure changes in costs associated with changes in health care utilization

in the intervention and non-intervention group beginning at 18. Age 65 is used as the endpoint in the public perspective analysis because virtually all subjects are eligible for Medicare at age 65. In the studies employing the societal perspective, the analytical horizon is human life expectancy.

In health economics, life expectancy and morbidity are measured as a single outcome called the "quality-adjusted life year," or QALY. One QALY is a year of life lived in perfect health. The QALY is comprised of two components, health related quality of life and years of life gained. Health related quality of life is a measure of morbidity that varies from zero to one, with zero equal to a state of death and one equal to perfect health (Gold et al 1996). The health related quality of life score is used to adjust life expectancy to reflect years of life in perfect health. For instance, a population with an average health related quality of life of 0.8 and a life expectancy of 80 years would have a quality-adjusted life expectancy of $0.8 \cdot 80 \text{ years} = 64$ QALYs.

Whether QALYs are included in the analysis depends on the perspective adopted. From the societal perspective, all costs are measured regardless of who pays. Thus, the total cost associated with an intervention that improves high school graduation rates is equal to the change in medical expenditures plus the cost of the intervention less the monetized gains in QALYs.

In the baseline analysis, I used a conservative estimate of QALYs that excluded lost productivity and leisure costs ($80,000). When lost productivity costs are excluded, it becomes possible to add health savings associated with increased educational attainment to wage increases presented elsewhere in this volume. When such costs are included, the total monetized QALY increases to $110,000. For a discussion of the monetized value of QALYs, please see the Technical Appendix.

b. The US health system

Heath care in the US is primarily paid for via payroll deductions, employer contributions, taxation, tax deductions (employers can deduct private insurance costs), and out of pocket payments (Iglehart 1999). Care for the uninsured is paid for via a combination of cost shifting, out of pocket payments, and government subsidies. From the public perspective, relevant costs arise from Medicare expenditures (which are supplemented by small payments made by enrollees), Medicaid expenditures (which are part federal and part state), employer tax deductions, and a large variety of categorical programs, including the armed forces. While increasing educational attainment may impact military enrollment as well as the health of enlisted personnel, these costs were not captured in the present analysis.

2. Estimation of effect size

The goal of the analysis is to capture the health effects that can reasonably be expected to arise from the upward mobility conferred by an educational intervention. To ensure that effects relevant to the population of interest (students receiving an educational intervention) were measured, I controlled for sociodemographic characteristics that are not modified by income: age, race, gender, and ethnicity. I then applied the sociodemographic characteristics of persons with a 10th or 11th grade education to this model, since this is the population to whom educational interventions will be applied.

There is general consensus in the economics literature that improving education improves earnings, and that standard linear regression models do a good job of predicting expected changes in earnings with changes in education (see Rouse elsewhere in this volume). However,

there is some uncertainty as to whether those receiving an education intervention that allows them to graduate from high school will garner them the same earnings potential as the average high school graduate (Carniero et al). Therefore, I included income as a covariate in the model in order to utilize more conservative estimates of income gains as predictors of health outcomes.

4. Datasets

To obtain expenditures, health related quality of life scores, and the probability of enrolling in private or public insurance by educational attainment, I used the 2002 Medical Expenditure Panel Survey (MEPS). The MEPS is a nationally-representative sample of over 40,000 non-institutionalized civilian subjects. The 2002 MEPS oversampled households with an income less than 200% of the poverty line. In addition to collecting detailed socio-demographic characteristics, and medical expenditures, the MEPS contains an instrument capable of producing health-related quality of life scores (see Technical Appendix for more information).

To obtain per enrollee costs within each segment of the insurance sector (public and private), I used the National Health Accounts (NHA) produced by the Centers for Medicare & Medicaid Services. The NHA is based on a number of separate data sources and presents health expenditures in the aggregate (Arnett et al 1990). The NHA estimates are systematically higher than those in the MEPS because it contains total budgets, not just medical expenditures (Selden et al 2001). For details on this analysis, see the Technical Appendix.

5. Findings

In this section, results are presented by payer perspective (societal and public). Potential costs associated with reducing the number of uninsured persons are also discussed from the

public perspective. Various case scenarios are presented in each section. In the first scenario, subjects are advanced from 11 years of education to a high school diploma. The assumption here is that only students with 10 to <12 years of education (a mean of 11 years) will benefit from an education intervention. This provides a conservative estimate of the health impact of most educational interventions because is does not account for any beneficial effects realized by students who receive the intervention but do not graduate from high school. It is also conservative because it does not account for any beneficial effects of education beyond high school on health (i.e., it assumes that no subjects will go to college).

In the second scenario, all 600,000 subjects who were high school dropouts at age 20 in 2004 are advanced one grade, and those with 11 or more years of education graduate from high school. This provides the reader with a sense of the potential national impact of a generic education intervention.

In the forth through ninth scenarios, students are administered various real world education interventions. In each case, only real world increases in high school graduation rates are considered (subjects are not promoted to college). The interventions evaluated include the Tennessee STAR program's class size reductions (targeted toward 5-year-olds), two pre-kindergarten interventions (the Chicago Child-Parent Centers and Perry/High Scope), a 10% teacher salary augmentation (targeted toward 5-year-olds), and a multifaceted intervention targeted toward 14-year-olds (Reynolds et al 2001; Schweinhart 2004). In each case, benefits are discounted from the point of the intervention, but benefits are conservatively assumed not to accrue until age 18.

a. Societal analysis

The linear regression models predicted that increasing educational attainment would produce a slight decrease in age-specific predicted expenditures for high school graduates, but a slight increase for college graduates (see Table 2). These expenditures are in line with data from the only randomized controlled trial of health insurance (see Table 1). Table 2 also contains QALYs over a one-year time period. While high school dropouts live, on overage, 0.89 QALYs between the ages of 18 and 19, high school graduates live 0.91 QALYs, and college graduates live 0.96 QALYs.

Discounted lifelong health care expenditures were $1,100 higher among those receiving an education intervention that promoted them from the 11th grade to the 12th grade than those who did not. These higher overall expenditures among those with a high school diploma were attributable to lower premature mortality; subjects with more education live longer, and therefore consume more health care. Between the ages of 18 and death, those receiving the education intervention pushing them from 11th grade to 12th grade were predicted to live 1.1 QALY longer than those who did not at a 3.5% rate of discount. The total estimated health savings (in monetized QALYs) associated with the education intervention are $85,000 per person. The total health loss over one cohort of high school dropouts is about $88.3 billion dollars.

Were the cohort of 600,000 dropouts in 2004 to advance 1 year in educational attainment, medical expenditures would increase by $500 million, 570,000 QALYs would be gained, and $46 billion dollars would be saved overall. Table 3 presents the costs associated with various real world education interventions after considering the monetary and medical savings that begin to accrue at age 18. Only one comprehensive intervention (the Quantum Opportunities program)

fails to produce cost savings from the societal perspective when medical and monetary savings are included.

Reducing the discount rate greatly increases savings. Undiscounted savings associated with promoting an 11th grader to 12th grade increases predicted lifetime savings from $85,000 to $195,000. Using an 8% discount rate reduces predicted lifetime savings to $36,000. Including lost productivity and leisure time increases total lifetime savings from $85,000 to $117,000. When lost productivity and leisure costs are added, this total increases to $110,000 per person.

Using average estimates for the monetized value of a QALY ($166,000) rather than the conservative estimates I employ in the baseline analysis ($80,000) increases savings to $178,000 from the societal perspective (Hirth et al 2000). Using this latter figure, $97 billion dollars would be saved with an education intervention that advanced all 600,000 high school dropouts by 1 grade. More detailed sensitivity analyses are presented in the Technical Appendix.

b. Public perspective

The regression models predicted that 15% of those in the hypothetical cohort with an 11th grade education would be enrolled in some form of public insurance. After promoting these students to a high school diploma, the predicted enrollment in public plans falls to 13%. The net effect of this drop in enrollment in public insurance plans is a savings of $3,000 per individual discounted over a lifetime at 3.5%. For the intervention promoting all 600,000 dropouts one grade, savings amount to $31.4 billion for the cohort over the 52-year span until subjects become eligible for Medicare. However, differences become much larger as years of completed education decrease below 11 years or beyond high school (see Table 4). Public savings associated with various real world interventions are presented in Table 3.

Table 5 presents public returns per student associated with various advances in

educational attainment over the lifetime of the subject at a 3.5% discount rate. Students who

would have dropped out at the 10th grade who went on to graduate from high school would save

the government $8,000 were they to graduate from high school as a result of an educational

intervention. However, were the student to go on to obtain 16 years of education, $21,000 would

be saved over the student's lifetime.

c. Costs associated with uninsured populations

The models predict that, when subjects are advanced from 11 years of education to high

school graduates, the chance of being uninsured falls from 19% of to 16%. Thus, subjects moved

off of public rolls are partially absorbed into private insurance pools, reducing the government's

cost of caring for the uninsured. These costs largely fall on state and local programs (Iglehart

1999).

By one estimate, approximately 33% of the cost of caring for the uninsured is borne by

the public sector, with cost-transfers from the private sector covering 66%, and philanthropy

covering under 2% (Thorpe 2005). According to these estimates, an intervention advancing all

600,000 dropouts by one grade would save federal, state, and local programs an additional $2.1

billion. Because the dataset used to estimate expenditures in the study by Thorpe (2005)

excluded many costs, the $2.1 billion figure may greatly underestimate costs (Selden et al 2001).

Increasing the number of insured persons is also associated with costs from the public

perspective. For the hypothetical intervention that advances all students one grade, federal tax

revenues would decrease by $6.8 billion (President's Commission 1999). The net effect of

increasing the number of insured persons with an educational intervention may therefore be to

shift a portion of the burden of medical costs from state and local governments onto the federal government. Because there is a large degree of error in these estimates and because reduced public burdens and tax deductions work in opposite directions, these costs are not included in other estimates presented in this study.

IV. Summary

Aggregated over a lifetime, a conservative valuation of the health losses associated with the 600,000 18-year-olds who failed to graduate from high school in 2004 is $88.3 billion dollars. In this volume, Rouse evaluated a hypothetical intervention that advanced these 600,000 high school dropouts one grade. Such an intervention would produce lifetime earnings gains of around $72 billion dollars. I find that health gains add $46 billion in returns to the investment.

Table 3 outlines the costs associated with various real world programs from both the public and societal perspectives. Medical savings contribute relatively little to the lifetime savings associated with these interventions from the public perspective, but constitute just under a third of the savings from the societal perspective.

While estimated savings are smaller than they were for the income analysis, real world savings would almost certainly be higher. For instance, utilizing a more realistic valuation of people's willingness to pay for a QALY would at least double the projected cost savings from a societal perspective. Assuming that some high school graduates would go on to college would greatly increase projected savings as well.

The major limitation of the analysis was its reliance upon cross-sectional data to estimate changes in expenditures and health-related quality of life scores. Although the analysis controlled for sex, race, gender, ethnicity, partially controlled for income, and applied

coefficients to a cohort representative of those who dropped out with 10 to 11 years of education, linear regression imperfectly approximates the effects of real world education interventions. For instance, linear regression analyses may be confounded by genetic effects, by childhood socio-economic circumstances, or by unforeseen factors. Conversely, education interventions may select for the brightest students from poor communities, or for students who have had fewer social obstacles or toxic exposures. The results presented here are only accurate to the extent that these countervailing biases cancel each other out.

Once longer-term data are available from earlier randomized controlled trials of educational interventions, it will be possible to match subjects to death certificate data, providing more accurate estimates of the effect size of educational interventions on mortality. However, a more comprehensive set of outcome measures than are now being collected in such trials is needed while the subjects are still alive. Specifically, subjects from existing studies of educational interventions should be administered QALY-compatible instruments in order to calculate health-related quality of life scores. The much more challenging task of obtaining medical expenditure data can be simplified by recording self-reported diagnoses and the number of visits to medical care providers (by the type of provider) at intervals reasonably short for the subjects to recall such visits. This would allow health economists to translate utilization data into opportunity costs.

From the societal perspective, the health gains produced by preschool and class size interventions alone may exceed the cost of such programs. Including reduced crime and increased earnings to the analysis only deepens the savings associated with such programs. From the public perspective, health gains may significantly help offset the cost of such interventions, with savings of $3,000 to $21,000 per student responding to the intervention.

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Figure 1. Selected plausible pathways through which education works to improve health. Education improves cognition, income, and occupational status while possibly improving the psychological milieu of the individual.
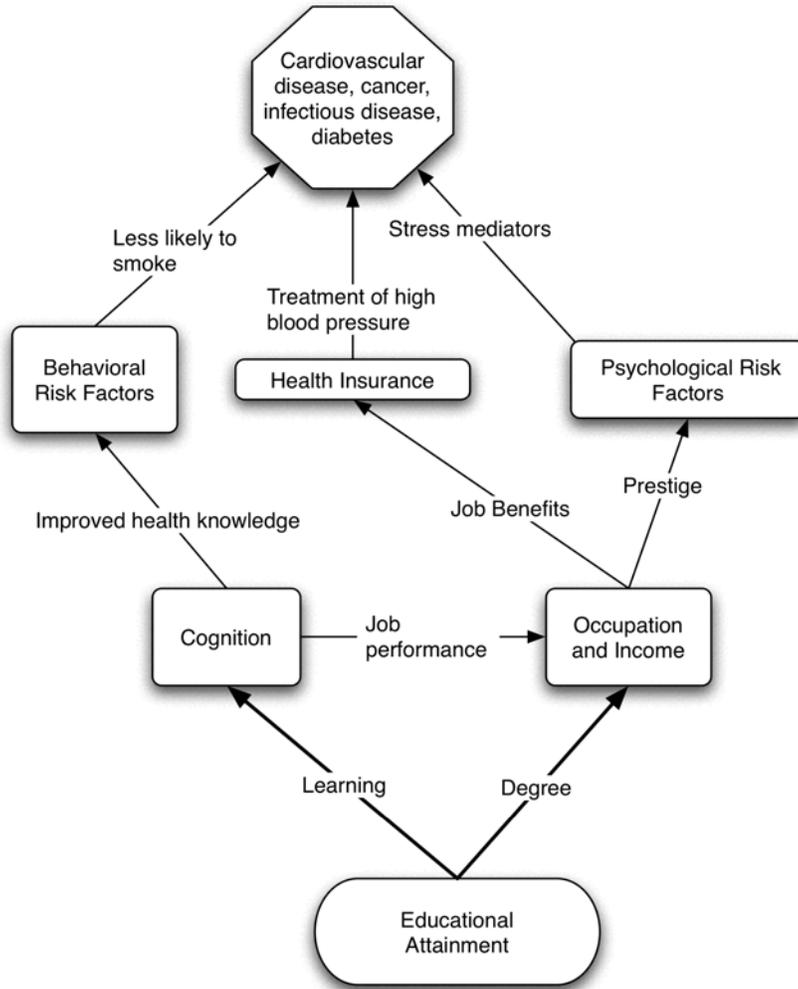
Figure 2. Education improves cognitive ability, thus possibly improving the assessment of

behavioral risks such as smoking or drinking and driving. Educational attainment also tends to

move persons away from manual labor jobs, reducing work related injury.
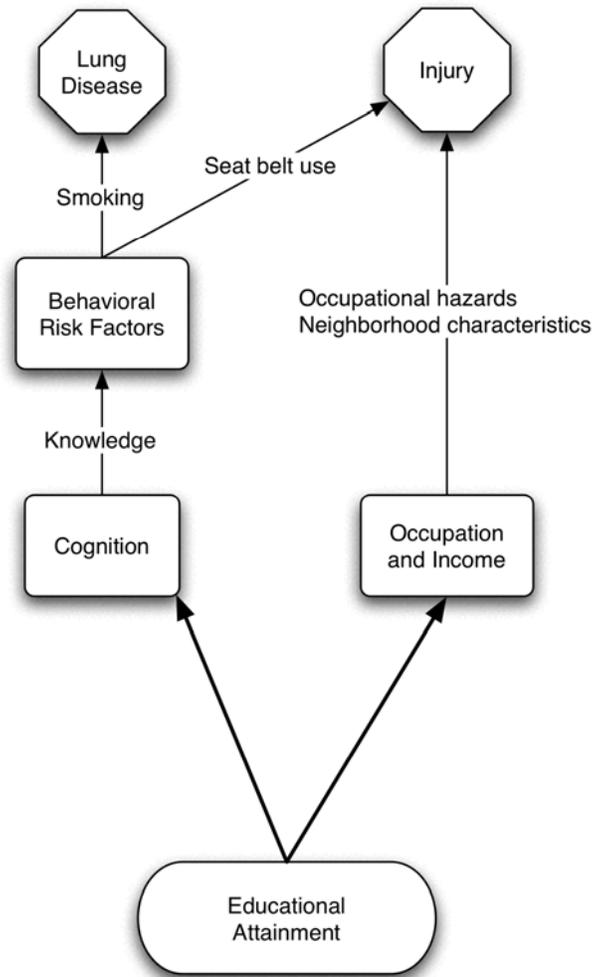
Table 1. Predicted medical utilization and expenditures by family income from the Rand Health Insurance Experiment.

	Income		
	Lower Third	Middle Third	Higher Third
Utilization (%)			
100% Coverage	83	87	90
50% Coverage	65	76	82
5% Coverage	62	74	79
Expenditures $US 2004[1]			
100% Coverage	$1,436	$1,341	$1,473
50% Coverage	$1,112	$1,002	$1,074
5% Coverage	$1,059	$901	$960

[1]Adjusted using the consumer portion, rather than the medical portion, of the consumer price index.

Table 2. Base case predictions of medical expenditures and health-related quality of life (HRQL) at specific ages.

Expenditures[1]

Age	11 Years	12 Years	HS Graduate
18	$443	$436	$449
28	$620	$611	$628
38	$867	$855	$880
48	$1,214	$1,196	$1,231
58	$1,699	$1,675	$1,723
68	$2,377	$2,344	$2,412

QALYs per year[2]

Age	11 Years	12 Years	HS Graduate
18	0.89	0.91	0.96
28	0.86	0.88	0.93
38	0.83	0.85	0.90
48	0.79	0.81	0.86
58	0.76	0.78	0.83
68	0.72	0.74	0.79

[1] Average annual age-specific medical expenditures on all types of care including out-of-pocket expenditures.

[2] Proportion of one year lived in perfect health.

Table 3. Various interventions by their cost, projected savings, and monetary returns per additional graduate from

	Intervention cost	Medical savings	Monetary savings
Public			
Class size[1]	$21,000	$2,100	$62,000
Chicago[2]	$49,000	$2,100	$60,000
Perry[3]	$53,000	$2,100	$60,000
Teacher salary	$135,000	$2,100	$62,000
Quantum	$322,712	$2,900	$85,000
Societal			
Class size	$21,000	$54,000	$168,000
Chicago	$49,000	$53,000	$162,000
Perry preschool	$53,000	$53,000	$162,000
Teacher salary	$135,000	$54,000	$168,000
Quantum	$323,000	$74,000	$229,000

[1] Tennessee STAR. Increasing class size from 25 students to 15 students (Krueger 1997).

[2] Chicago Child-Parent Centers. Preschool intervention program (Reynolds et al 2001).

[3] Perry/High Scope. Preschool intervention program (Schweinhart 2004).

[4] Augmenting teacher salaries by 10%. Details not available in this draft.

[5] Quantum Opportunities. Multiple interventions combining financial incentives with various other approaches (La

Table 4. Predicted and actual percentages of publicly insured, privately insured, and uninsured persons by educational attainment.

Education	Insurance		
	Public	Private	Uninsured
Percent Distribution			
$< 9^1$	24%	48%	28%
10 to $< 12^1$	15%	58%	27%
High school graduate	13%	71%	16%
College graduate	7%	86%	7%

[1]Values reflect mean attainment levels within category according to the 2004 March Current Population Survey. Those with < 9 years of education have, on average, completed 7.7 years, and those with 10 to < 12 years have completed an average of 11.1 years of school.

Table 5. Lifetime cost-savings from a public perspective of promoting students between 10, 12, 14, and 16 years

Grade	10	12	14	
10	0	$8,141	$15,395	$2(
12	$8,141	0	$6,317	$1
14	$15,395	$6,317	0	$4
16	$20,840	$4,760	$4,760	