

Dench, Daniel; Grossman, Michael

Working Paper

Health and the Wage Rate: Cause, Effect, Both, or Neither? New Evidence on an Old Question

IZA Discussion Papers, No. 11943

Provided in Cooperation with:

IZA – Institute of Labor Economics

Suggested Citation: Dench, Daniel; Grossman, Michael (2018) : Health and the Wage Rate: Cause, Effect, Both, or Neither? New Evidence on an Old Question, IZA Discussion Papers, No. 11943, Institute of Labor Economics (IZA), Bonn

This Version is available at:

<https://hdl.handle.net/10419/193237>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

DISCUSSION PAPER SERIES

IZA DP No. 11943

**Health and the Wage Rate: Cause, Effect,
Both, or Neither?
New Evidence on an Old Question**

Daniel Dench
Michael Grossman

NOVEMBER 2018

DISCUSSION PAPER SERIES

IZA DP No. 11943

Health and the Wage Rate: Cause, Effect, Both, or Neither? New Evidence on an Old Question

Daniel Dench

City University of New York Graduate Center

Michael Grossman

*City University of New York Graduate Center, National Bureau of Economic Research
and IZA*

NOVEMBER 2018

Any opinions expressed in this paper are those of the author(s) and not those of IZA. Research published in this series may include views on policy, but IZA takes no institutional policy positions. The IZA research network is committed to the IZA Guiding Principles of Research Integrity.

The IZA Institute of Labor Economics is an independent economic research institute that conducts research in labor economics and offers evidence-based policy advice on labor market issues. Supported by the Deutsche Post Foundation, IZA runs the world's largest network of economists, whose research aims to provide answers to the global labor market challenges of our time. Our key objective is to build bridges between academic research, policymakers and society.

IZA Discussion Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. A revised version may be available directly from the author.

ABSTRACT

Health and the Wage Rate: Cause, Effect, Both, or Neither? New Evidence on an Old Question*

We investigate two-way causality between health and the hourly wage by employing insights from the human capital and compensating wage differential models, a panel formed from the National Longitudinal Survey of Youth 1997, and dynamic panel estimation methods in this investigation. We uncover a causal relationship between two of five measures of health and the wage in which a reduction in health leads to an increase in the wage rate in a panel of U.S. young adults who had completed their formal schooling by 2006 and were continuously employed from that year through 2011. There is no evidence of a causal relationship running from the wage rate to health in this panel. The former result highlights the multidimensional nature of health. It is consistent with an extension of the compensating wage differential model in which a large amount of effort in one period is required to obtain promotions and the wage increases that accompany them in subsequent periods. That effort may cause reductions in health and result in a negative effect of health in the previous period on the current period wage. The finding also is consistent with a model in which investments in career advancement compete with investments in health for time- the ultimate scarce resource. The lack of a causal effect of the wage on health may suggest that forces that go in opposite directions in the human capital and compensating wage differential models offset each other.

JEL Classification: I10, J24

Keywords: health, wage, causality

Corresponding author:

Michael Grossman
Ph.D. Program in Economics
City University of New York Graduate Center
365 Fifth Avenue, 5th Floor
New York, New York 10016-4309
United States
E-mail: mgrossman@gc.cuny.edu

* This paper was presented at an IZA conference titled "Health and the Labor Market" in Bonn, Germany, November 3-4, 2017. We would like to thank, two anonymous reviewers, Solomon W. Polachek, Konstantinos Tatsiramos, conference participants, and Ilene J. Grossman for helpful comments and suggestions.

I. Introduction

Both the human capital model and the compensating wage differential model generate relationships between health and the wage rate. In Grossman's treatment of health as a form of human capital, he draws a sharp distinction between health capital and other forms of human capital, which he refers to as knowledge capital (Grossman 1972a, 1972b, 2000, 2017).

Investments in knowledge capital raise wage rates, while investments in health capital raise the total amount of time available for market and household production in a given year and prolong length of life. That treatment suggests, however, important complementarities between the two forms of human capital. Returns to investments in knowledge are higher the more time that is available for market and household production, especially if productivity in both sectors is positively related to the stock of knowledge. Returns also are higher the longer are the number of periods that the investor lives. Returns to investments in health are larger the greater is the monetary value of the increase in healthy time and length of life. The wage rate of the investor is the most direct measure of this monetary value. These complementarities suggest causality from knowledge capital to health capital and from health capital to knowledge capital.¹

The compensating wage differential model, which dates to Adam Smith (1937), was formalized in a seminal paper by Rosen (1974).² This model emphasizes that wage offers may

¹ Despite these complementarities and the two-way causality they suggest, Grossman (1972a, 1972b) treats knowledge capital as exogenous in his theoretical model of the demand for health. Galama and van Kippersluis (2016) construct a rich theoretical model in which both types of capital are endogenous. Their model allows for a complex and intriguing set of interactions and complementarities between health capital and knowledge capital. To date, it has not been used as the basis of empirical work. In our view, attempts to specify and estimate this model will be very rewarding.

² For comprehensive reviews of this literature, see Rosen (1986) and Viscusi (1993, 2014). We use the term compensating wage differentials to distinguish the negative health-wage relationships in a model with health-wage tradeoffs from positive health-wage relationships due to complementarities in the human capital model. Of course, the higher wages offered to the more educated be viewed as compensating them for the earnings they forego for attending school for more years than their less educated colleagues. So our terminology, is simply a "short-hand" way to distinguish between the two basic reasons for expecting relationships between health and the wage.

have to be adjusted upwards to compensate for health risks associated with specific jobs, occupations, and industries. Thus, in stark contrast to the human capital model, it generates negative relationships between health and the wage rate.

In this paper we use the hourly wage rate—the most comprehensive measure of the stock of knowledge of investors who have completed training—and a number of measures of health to investigate two-way causality between health and the wage. We do this in a panel formed from National Longitudinal Survey of Youth 1997. We employ dynamic panel models (for example, Arellano 2003, Baltagi 2008) in this investigation. We employ plausible specifications in which a change in health induces a change in the wage with a lag and in which a change in the wage induces a change in health, also with a lag.

II. Background

A. Human Capital Model

Grossman and others who conducted empirical tests of his 1972 model of the demand for health have not explored complementarities between health capital and knowledge capital just outlined in detail (see Grossman 2000 for a discussion of empirical studies related to those in Grossman 1972b). Instead, the approach in this empirical literature has been to treat both schooling and wage rates as exogenous or more formally as predetermined variables that are not correlated with the disturbance term in the health outcome equation. Separate estimates of the effect of each have been obtained to explore the hypothesis that an increase in schooling can increase the demand for health, with the wage rate held constant, because it raises the efficiency with which health is produced, or because it changes the mix of inputs selected by the investor. On the other hand, higher wage individuals demand more health, with schooling held constant,

because their monetary rates of return to investments in health exceed those of individuals with lower wage rates.³

In general, the research just mentioned finds positive effects of schooling and the wage rate on a variety of correlates of good health. The question of whether some portion of these effects reflects causality from health capital to knowledge capital is left open. In addition, the possibility that an unobserved “third variable” causes both types of capital to vary in the same direction is not addressed.

A rich empirical literature in health economics reviewed by Grossman (2006, 2015, 2017) addresses causality between correlates of knowledge capital and health capital in a thorough manner. Studies in this literature employ years of formal schooling completed as the measure of knowledge capital and a number of different correlates of better health. Much of the emphasis is on the estimation of causal effects of more schooling on the health of the investor or on her or his children. Some studies, however, seek to uncover causal effects of early investments in the health, cognitive, and noncognitive development of children on later outcomes.

Part of our contribution in this paper is grounded in the literature just discussed but takes a somewhat different approach. Instead of measuring knowledge capital by completed schooling, we measure it by the hourly wage rate. This is a better measure of knowledge capital than schooling because it encompasses on-the-job training as well as schooling. In Ben-Porath’s seminal contribution on investment in human capital over the life cycle (Ben-Porath 1967), he defines earnings potential (the value of knowledge) as RK , where R is the rental price per unit of human capital and K is the amount of that capital. As opposed to the literature on the

³See below for qualifications of these predictions.

relationship between schooling and health, we employ an hourly version of RK.⁴ And instead of estimating only a health equation or only a knowledge (proxied by schooling) equation, we estimate equations for both types of human capital.

Our approach is not an entirely new one. Grossman and Benham (1974), Grossman (1976), and Lee (1982) estimate simultaneous-equations health-wage models in cross-sectional data. These studies are motivated by considerations briefly mentioned in the introduction to this paper. In that section we pointed out that returns to investments in health are larger the greater is the marginal benefit of the increase in healthy time and length of life. The wage rate of the investor is the most direct measure of these benefits. One necessary condition for the marginal rate of return on the investment to rise is that the own time of the investor is not the only input in the production function of investment in health. In that case, the percentage increase in the marginal benefit of an investment exceeds the percentage increase in its marginal cost. A second necessary condition that underlies the prediction of a positive wage coefficient in the health demand function is that health is what Grossman (1972a, 1972b) terms a “pure investment commodity” because it does not enter the utility function. The prediction becomes complicated in a model in which health is both an investment commodity and a “consumption commodity” (a commodity that enters the utility function directly) because one has to take account of how the marginal cost of investment changes relative to the marginal costs of other household commodities.⁵ Even if the relative price of health rises, the resulting negative substitution effect may be offset or more than offset by a positive income or wealth effect.

⁴ If forces in the compensating wage differential model are present, the wage rate no longer is the most comprehensive measure of the stock of knowledge capital or more generally of the stock of human capital. See Section II.B for more details.

⁵ These necessary conditions also are required to justify the predications made by Grossman and Benham (1974), Grossman (1976), and Lee (1982) about the effects of an increase in years of formal schooling completed on health, with the wage rate held constant.

Returns to investments in knowledge are higher the more time that is available for market and household production, especially if productivity in both sectors is related to the stock of knowledge. Returns also are higher the longer are the number of periods that the investor lives. While these factors typically are used to explain why better health may cause more schooling, they also are relevant to investments in knowledge made after the completion of school. Grossman (2006) summarizes evidence suggesting that students' health influences their productivity in school. Reasoning by analogy, should not adults' health influence their productivity in the labor market? For example, individuals who miss a significant amount of time at work due to illness may lose the opportunity to advance by undergoing intensive computer training. Ultimately, that may hinder their opportunities for promotion, result in lower wage rates, and less facility with the use of computers in home production. More generally, Mincer (1974) stresses that investment in on-the job training, measured by the total amount of time spent in such an activity, plays a major role in the wage function in his seminal treatment of that function. That variable is imperfectly measured in most datasets. To the extent that poor health reduces the amount of time spent in the labor market and opportunities to invest in on-the-job training, past health may affect the current wage via its impact on past investment in that training.

There is, however, a factor associated with on-the-job training that may result in a negative effect of health on the wage, especially if lagged relationships are considered. Rosen (1972) argues that on-the-job training is a joint product of hours of work and the existing stock of human capital. In that case, investments in career advancement compete with investments in health for time—the ultimate scarce resource.⁶

⁶ Ben-Porath (1967) assumes that hours of work and hours allocated to investment in human capital are divisible inputs. In either case investments in career advancement compete with investments in health for the own time of the

To explore bi-directional causality between health and the wage, Grossman and Benham (1974) employ white males in the 1963 health interview survey conducted by the National Opinion Research Center (NORC) and the Center for Health Administration Studies of the University of Chicago. They measure health as an index formed from the first principal component of the number of symptoms reported from a checklist of twenty common symptoms and individuals' self-evaluation of their general health as excellent, good, fair, or poor. Grossman (1976) employs the National Bureau of Economic Research-Thorndike sample, which contains data on high ability white males in 1968 and additional data in 1971. He employs the self-rated health variable just defined and scaled so that it is proportional to the average number of work-loss weeks due to illness of men in poor health relative to the average number of work-loss weeks due to illness of men in each of the three other categories. Lee (1982) focuses on all males in the National Longitudinal Survey of Men 1966. He uses a multiple indicator model in which self-rated health and the presence of health conditions that affect the kind or amount of work are indicators of the unobserved stock of health. Grossman and Benham (1974) and Grossman (1976) obtain estimates by conventional two-stage least squares methods. Lee (1982) applies maximum likelihood methods to a specification that incorporates a multiple indicator model with measurement error and endogenous right-hand-side variables in each of the two structural equations.

All three studies report positive and significant effects of increases in better health in the wage equation. Grossman (1976) and Lee (1982) also find positive and significant wage coefficients in the health equation, but Grossman and Benham's (1974) coefficient is not

investor. Rosen's assumption is more relevant to our extension of the compensating wage differential model in Section II.B in which an increase in work hours and effort in one period have direct negative effects on health but result in wage gains in subsequent periods.

significant. All three studies treat potentially endogenous variables as exogenous and impose questionable exclusion restrictions. For example, years of formal schooling is exogenous in the health and wage equations in all three studies. Grossman (1976) assumes that a correlate of obesity and an indicator of job satisfaction are exogenous in the health equation and do not enter the wage equation. He also excludes region and city size indicators from the health equation while including them in the wage equation. Grossman and Benham (1974) and Lee (1982) also employ this exclusion restriction. In addition, Lee includes an indicator variable for nonwhites in the wage equation, while excluding it from the health equation. Grossman and Benham assume that the length of time that has elapsed since the last physical examination is an exogenous regressor in the health equation, while Lee assumes that assets are an exogenous variable in that equation.

B. Compensating Wage Differential Model

In the compensating wage differential model, consumers tradeoff an increase in job risk, reflected by the probability of a fatal or nonfatal accident or injury, in return for a higher wage rate. Since the production of safety is costly, firms are willing to reduce the accident probability only if they can offer a lower wage rate. Market equilibrium is determined by the point of tangency between a given worker's expected utility function and a given firm's isoprofit curve. Since firms and consumers differ, the connection of these points of tangency generates an upward sloping function termed the equilibrium market wage-risk function or the hedonic wage function. As discussed in detail by Rosen (1974, 1986) and Viscusi (1993, 2014), the complete model consists of this function, a demand function for safety by consumers, and a supply function of safety by firms.

For our purposes, the market equilibrium function is the most relevant one. Typically, the wage is measured at the individual level, but the risks are injury or death rates at the occupation or industry level. Extensive reviews of this literature are contained in Rosen (1986) and Viscusi (1993, 2014). The finding that an increase in job risk is associated with an increase in the wage is universal, once one controls for worker characteristics. Almost all of these studies treat job risk as exogenous because they are imbedded in a model that views the equation that is estimated as one that depicts market equilibrium.⁷ The study by Kniesner, Viscusi, Woock, and Ziliak (2012) is one exception. They use panel data for men ages 18 through 65 in the Panel Study of Income Dynamics for the years 1993, 1995, 1997, 1999, and 2001. Since they employ a first-difference specification, most of the variation in fatality risk is due to job changes, which may be caused by wage changes. Hence, they instrument the first difference of the fatality risk with lagged levels and differences of that variable.

We modify the compensating wage differential framework because our health measures are specific to an individual rather than to an industry or occupation and because we examine the health-wage relationship in a relatively young panel in which job changes are rare. Hence, a person who accepts a relatively high wage offer in one period may incur a reduction in health in a subsequent period because the offer he or she accepted was associated with health risks. That suggests a negative effect of the lagged wage on current health.

⁷ Based on an estimation strategy proposed by Rosen (1974), a number of authors have estimated the demand function or the supply function that complete the model. These estimates first compute marginal prices from the market equilibrium equation and then treat it and safety as endogenous variables. For reviews of these studies and a new estimation procedure that has not yet been implemented at the empirical level, see Ekeland, Heckman, and Nesheim (2004) and Heckman, Matzkin, and Nesheim (2010).

On the other hand, the acquisition of a chronic condition that shortens life expectancy may lead to an increase in effort in an attempt by the head of a household to provide for his or her family, which may be associated with promotions and higher wages in future periods. Moreover, suppose there is imperfect information about the effort requirements of a particular job on the part of employees when they are hired and similar imperfect information about the amount of effort new hirers are willing to exert on the part of employers. Also assume that increases in effort have negative effects on health. Then employers have incentives to reward workers who are willing to exert more effort in one period in terms of promotions and the wage increases that accompany them in subsequent periods. Along the same lines, employees have incentives to exert more effort in order to earn these wage gains.

The metaphor of “working oneself to death” is relevant here. Indeed, Inoue and Specia (2017) describe the death of a thirty-one year old female journalist for Japan’s state-run TV network from congestive heart failure in July 2013. She died after working 159 hours of overtime during the previous month in order to cover two local elections in Tokyo. Her death, termed *karoshi* or “death from overwork” by the Japanese, has been widely recognized since the late 1980s in Japan. Cases first were reported among blue-collar workers, but they also have occurred among white-collar executives.

Schreier (2017) describes another example of the negative effect of overwork on health. Video game developers frequently experience what is termed a “crunch” or spike in work hours. During the spike, which can last for weeks, they are required to work as many as 20 hours per day and sleep at work. One such worker, who experienced the spike in order to fix bugs and add features to the role-playing game “The Elder Scrolls V: Skyrim,” experienced severe stomach

pains that required the individual to take a few weeks off from work. Another game developer who experienced a crunch was temporarily unable to step out of his car.

C. Summary

Both the human capital model and the compensating wage differential model generate relationships between health and the wage rate. In the pure investment component of the former model, an increase in the wage causes health to increase as long as the own time of the investor is not the only input in the health production function. This prediction becomes ambiguous in a mixed consumption-investment model because the relative price of health may increase substantially if its production is much more time intensive than the production of other household commodities. In addition, in the human capital model an increase in health should increase investments in knowledge and hence the wage after the completion of formal schooling because more time is available for market and nonmarket production and because the number of periods over which returns can be collected grows. That prediction becomes ambiguous, however, if on-the-job training is a joint product of hours of work and competes for scarce time with investments in health. On the other hand, the compensating differential model generates negative causal effects from health to the wage and from the wage to health. Current period reductions in health might have been avoided if a lower initial wage offer had been accepted. Moreover, large amounts of effort in previous periods might result in reductions in health in that period and in raises and promotions in the current period.

By implementing dynamic panel data models that allow lagged levels of health and the wage to be specified as instruments for differences of right-hand side measures of these variables on theoretical grounds, we relax the arbitrary identification assumptions in the studies by Grossman and Benham (1974), Grossman (1976), and Lee (1982). By incorporating insights

from the compensating differential literature, we make a stronger case as to why there may be relationships between health and the wage rate. At the same time, we justify why we are somewhat agnostic about the signs of these relationships.

III. Specification of Structural Equations

Consider a panel of n individuals, all of whom have completed their formal schooling. Let W_{it} be the wage rate or the log of that rate of the i th person in period or time t and H_{it} be a measure of the health of that person defined such that it is a positive correlate of better health. Omitting intercepts, period indicators, and period-varying observed exogenous variables, we specify the wage and health equations as follows:

$$W_{it} = \alpha_1 H_{it-1} + \alpha_2 W_{it-1} + f_i + u_{it} \quad (1)$$

$$H_{it} = \beta_1 W_{it-1} + \beta_2 H_{it-1} + g_i + v_{it}. \quad (2)$$

In these equations f_i and g_i are unobserved fixed effects (effects that do not vary by period) and u_{it} and v_{it} are unobserved effects that vary by period (unobserved time-varying effects).

Inclusion of unobserved fixed effects (f_i and g_i) and period-varying unobserved effects (u_{it} and v_{it}) that may be correlated with each other and with the observed variables incorporates biases due to such hard-to-measure ‘third variables’ as time preference (for example, Fuchs 1982; Grossman 2000).

We use equations (1) and (2) to examine the extent of two-way causality between health and the wage rate just outlined and standard dynamic panel methods (for example, Arellano 2003; Arellano and Bond 1991; Arellano and Bover 1995; Baltagi 2008; Blundell and Bond 1998) to estimate them. First we take the first difference of each equation to eliminate the period-invariant fixed effects:

$$(W_{it} - W_{it-1}) \equiv \Delta W_{it} = \alpha_1 (H_{it-1} - H_{it-2}) + \alpha_2 (W_{it-1} - W_{it-2}) + (u_{it} - u_{it-1}) \quad (3)$$

$$(H_{it} - H_{it-1}) \equiv \Delta H_{it} = \beta_1(W_{i-1t} - W_{it-2}) + \beta_2(H_{it-1} - H_{it-2}) + (v_{it} - v_{it-1}). \quad (4)$$

Following standard practice in the dynamic panel methods literature, we assume that current values of the wage and health are correlated with current and past values of disturbance terms but not with future values. Given those assumptions, equations (3) and (4) cannot be estimated by ordinary least squares. One consideration is that the lag of the first difference of the dependent variable in each equation is correlated with the disturbance term in that equation. For example, $\Delta W_{it-1} \equiv (W_{it-1} - W_{it-2})$ is correlated with Δu_{it} because W_{it-1} is correlated with u_{it-1} . Along the same lines, the lagged first difference of health in equation (4) is correlated Δv_{it} . A second consideration is that the lagged first difference of health in equation (3) and the lagged first difference of the wage in equation (4) are correlated with the respective disturbance term in each equation because u_{it-1} and v_{it-1} are correlated.

Given these considerations, we use the second lag of health (H_{t-2}) and longer lags of that variable as instruments for the lag of the first difference of health at time t in estimating the two equations. Those variables are not correlated with Δu_{it} or with Δv_{it} . For the same reason, we use the second lag of the wage and longer lags of the wage as instruments for the lag of the first difference of that variable at time t .⁸

On theoretical and empirical grounds, we do not consider a model in which current health enters the structural equation for the current wage and in which the current wage enters the

⁸ Both H_{t-1} and W_{t-1} are predetermined variables in equations (1) and (2) because they are correlated with past values of the disturbance term in each equation but not with the current value of that term. Technically, since H_{it-1} is a predetermined variable, it is correlated with u_{it-2} and longer lags of the disturbance term but is not correlated with u_{it} and u_{it-1} . Strictly speaking that assumes there would be no need to instrument for the lagged difference of health in equation (3). Since, however, it is unrealistic to assume that u_{it-1} and v_{it-1} are uncorrelated, we treat the lagged difference of H_{it} in equation (3) in the same manner as we treat the lagged difference of W_{it} in that equation, and instrument it with the second lag of H_{it} and longer lags. Along the same lines, we instrument the lagged wage in equation (4) with the second lag of that variable and longer lags. Given that our panel contains only five observations per person (see below), we cannot employ lags longer than one period in equations (1) and (2).

structural equation for current health. Theoretically, they incorporate the plausible assumption that the causal effects (α_1 and β_1) occur with a lag. Our specification is consistent with the notion of causality developed by Granger (1969) because it investigates, for example, whether past health predicts the current wage with the past wage held constant. These cross-lagged effects emerge for reasons specified in Section II. The lagged effects of the dependent variable in each equation arise because the presence of rising marginal costs of investment imply that the optimal stock of health and knowledge are reached gradually rather than instantaneously (Ehrlich and Chuma 1990; Galama and van Kippersluis 2016).

Empirically, consider a model in which current health, for example, enters the structural equation for the current wage [equation (1)] rather than the first lag of health. In that case, the first difference of health ($H_{it} - H_{it-1}$) replaces the lag of the first difference of health ($H_{t-1} - H_{t-2}$) on the right-hand side of equation (3)—the equation for the first difference of the wage. The problem here is that the first lag of health (H_{t-1}) cannot be used as an instrument for the first difference of health because it is correlated with part of the disturbance term in that equation— u_{it-1} . So the second lag of health and longer lags are the valid set of instruments. But the second lag of health simply is not a good predictor of the first difference of health in our data. The same point holds for longer lags of health. If current health is treated as a predetermined variable the same problem arises because we allow for the current values of the period-varying unobserved effects in equations (1) and (2)— u_{it} and v_{it} , respectively, to be correlated with each other.

IV. Data and Measurement of Variables

Our panel data come from the National Longitudinal Survey of Youth 1997 (NLSY97). This is a sample of the United States population consisting of 8,984 individuals who were ages 12-16 as of December 31, 1996. Two subsamples make up the NLSY97 cohort. The first is a

nationally representative sample of 6,748 respondents. The second consists of 2,236 oversampled black non-Hispanics and Hispanics. The cohort was interviewed each year from 1997 through 2011 and every other year starting in 2013. Since the maximum number of health measures are available in the period from 2007-2011, we limit our sample to individuals who reported data in all five of those years, had completed their formal schooling by 2006, and were in the labor force throughout that period. Our working data set contains 2,497 persons and 11,325 person-years. We have fewer than five observations for some individuals due to missing information on key variables. There are, however, no significant differences between our working data set and the larger sample. A majority of the sample range in age from 23 through 27 in 2007 and from 27 through 31 in 2011.⁹

We employ six dependent variables: the log of the hourly wage rate and five alternative measures of health. The wage rate itself is the one reported by the respondent on his or her full- or part-time job. If a respondent has a full-time and a part-time job, then the wage from the full-time job is used. If he or she has multiple full-time jobs, the simple average of the full-time jobs is used. If a respondent has multiple part-time jobs and no full-time jobs the simple average of the part-time jobs is used.

The health measures are self-rated health, an indicator of whether health limits the kind of work a respondent can do, an indicator of whether health limits the amount of work a respondent can do, the number of times a respondent was injured or ill in the past year and not treated by a physician or a nurse, and the number of times a respondent was injured or ill and was treated by a physician or a nurse. We employ five measures of health to account for its multidimensional nature. Moreover, some measures may be more relevant than others for

⁹ We do not employ the National Longitudinal Survey of Youth 1979 in this paper because it contains fewer health measures than NLSY97, and the measures appear sporadically rather than on a continuous basis.

workers who differ by education, gender, type of occupation, and race/ethnicity. We explore this issue after presenting our main results.

The last two health variables just specified range from zero through four or more. We assign a value of four to the top-coded category. Except for self-rated health, all of these measures are negative correlates of better health.

Self-rated health has five categories: excellent, very good, good, fair, and poor. We scale this variable using a procedure developed by Grossman (1972b, 1976). He considers the number of healthy work days (D) in a year as the output produced by health capital (H) and notes that this output has a finite upper limit of 250 days under the assumption that individuals work five days a week for fifty weeks. Then a plausible form of the production function of D is

$$D \equiv 250 - S = BH^C, \quad (5)$$

where S is the number of work-loss days due to illness or injury and B and C are positive constants. Solve equation (5) for H to obtain

$$H = B^{1/C}S^{-1/C}. \quad (6)$$

Let S_P , S_F , S_G , S_V , and S_E be mean work-loss of people in poor, fair, good, very good, and excellent health, respectively. Grossman views health capital as a units-free measure in an index number form with $H_P = 1$. Hence, $H_F/H_P = (S_P/S_F)^{1/C}$, etcetera.

Work-loss days are not reported in NLSY97, but they are reported in the U.S. National Health Interview Survey. We pool survey years 2005 through 2013 to obtain $H_F/H_P = 2.01$, $H_G/H_P = 4.33$, $H_V/H_P = 6.72$, and $H_E/H_P = 9.57$. That series assumes that the unknown constant C in equation (6) is equal to one. To relax that assumption, the natural logarithm of the scaled self-rated health measure is the right-hand side variable in the estimation of equation of the wage equation and the left-hand side variable in the estimation of the health equation. In the former

case, the regression coefficient and its standard errors are divided by $1/C$, and in the latter case, they are multiplied by C . Since C is an unknown constant, tests of significance are unaffected.

Means and standard deviations of the six dependent variables are contained in Table 1. These summary statistics are not weighted to correct for the oversampling of minorities because we estimate unweighted regressions in the next section. These estimates are very similar to weighted regressions. In addition, we fit separate regressions for whites, black non-Hispanics, and Hispanics after presenting our main results.

In addition to presenting the standard deviation of each variable in Table 1, we decompose that measure into between- and within-person components. That decomposition is important because our estimates would be biased if the within-person variation was small relative to the between person variation (Blundell and Bond 1998). According to the table, that decidedly is not the case. In almost all cases, the within component is at least as large as the between component.

Table 2 contains key characteristics of our sample, including potential independent variables. We do not control for observed time-invariant variables in the regressions because these variables drop out when first differences are taken. As, however, just indicated, we do fit separate models by race-ethnicity after we obtain our main results. We do the same for gender, education, and occupation. We include survey year and age indicators (ten age indicators, with age 22 the omitted category) in the health equations and survey year and potential experience indicators (14 indicators with 0 the omitted category) in the wage equations. We omit the other time-varying variables in Table 2 (married, spouse present; number of kids; own income excluding earnings; and spouses' income) because these variables are endogenous and because

we want to focus on the two key endogenous variables in our model. We note, however, that our results are not affected when these variables are included and treated as exogenous.

Our estimates are limited to continuously employed workers. That raises a standard selection issue because reductions in health could lead not only to effects on wages but also to spells out of the labor force. Ideally, we would want to estimate an econometric model that both deals with the simultaneity issue, as we do, and with the selection issue. One reason we have chosen not to estimate a sample selection model is that this model is not highly credible without theoretically-based exclusion restrictions. A second reason is that the three previous papers (Grossman and Benham 1974; Grossman 1976; Lee 1981) that estimated simultaneous equations health-wage models limited their estimates to workers in the labor force. We return to this issue in discussing our key results.

V. Results

Arellano-Bond dynamic panel estimates of the generalized methods of moments (GMM) first-differenced health and wage equations are contained in Tables 3 and 4, respectively. Since there are five alternative health measures, five regressions are shown in each table.¹⁰ Of the maximum of five observations for each person, the first one is lost because of the inclusion of the first lag of the wage and health in the specification of the structural level equations. The second one is lost by taking first differences. Hence, a maximum of three observations remain: the first difference as of 2009, the first difference as of 2010, and the first difference as of 2011. Missing data can limit this number to one or two for some persons. That is why the number of observations in Tables 3 and 4, which pertain to first differences of the dependent variables in

¹⁰ Estimates were obtained using the `xtabond2` routine in *Stata* (Roodman 2009).

the regressions, are less than 7,497 person-years (2,497 persons * 3 observations per person).¹¹

The estimates in each table employ up to three lags of health and up to three lags of the wage as instruments. In the first period (2009), the only available instruments are the second lags of these two variables—their values as of 2007. In the second period (2010), the second and third lags are available (values as of 2008 and 2007). In the third period (2011), all three lags are available (values as of 2009, 2008, and 2007).

Blundell and Bond (1998) point out that the performance of the GMM first-difference estimator has a large finite sample bias and poor precision when the autoregressive parameters are relatively large and the number of time series observations is small. Lagged levels of the series provide weak instruments for first differences in this case. They suggest using an extended GMM estimator that employs lagged differences as instruments for equations in level form, in addition to lagged levels as instruments for equations in difference form.

Before obtaining the estimates in Tables 3 and 4, we explored this issue by estimating an exactly identified version of our model. In this version, there are only two instruments: the second lag of health and the second lag of the wage. Since the equations are exactly identified, the Arellano-Bond first difference procedure is identical to conventional two-stage least squares. Following Blundell and Bond (1998), our evaluation is based on the first stage of the exactly identified model. Consider the structural equations for W_{it-1} and H_{it-1} . Subtract W_{it-2} from each side of the first equation, and subtract H_{it-2} from each side of the second equation to obtain

$$W_{it-1} - W_{it-2} = \alpha_1 H_{it-2} + (\alpha_2 - 1)W_{it-2} + f_i + u_{it-1} \quad (7)$$

$$H_{it-1} - H_{it-2} = \beta_1 W_{it-2} + (\beta_2 - 1)H_{it-2} + g_i + v_{it-1}. \quad (8)$$

¹¹ Note that the data in Table 1 pertain to variables in levels and include five observations per person in most cases.

Equations (7) and (8) constitute the first stage. Note that the fixed effects appear in the equations, and the second lag of the wage and the second lag of the health are correlated with those effects. But those two variables are not correlated with the disturbance terms in equations (3) and (4), which are $u_{it} - u_{it-1}$ and $v_{it} - v_{it-1}$, respectively. In this sense, the second lags are valid instruments.

Blundell and Bond show that parameter estimates of $\alpha_2 - 1$ and $\beta_2 - 1$ are inconsistent because the second lags of the wage and health are correlated with the fixed effects. The biases or inconsistencies are upwards towards zero and are particularly severe as α_2 and β_2 approach one and/or if the variance in the fixed effect relative to the variance in the time-varying disturbance term approaches infinity. In either case, an F-test of the significance of the two instruments as a set should have a small value.

The relevant F-ratios are reported in the last two rows in Tables 3 and 4. In the former table they range from 93.67 to 96.05 in the first-stage wage equation and from 163.50 to 851.2 in the first-stage health equation. In Table 4, the corresponding range is from 81.12 to 84.06 in the first-stage wage equation and from 154.30 to 749.50 in the first-stage health equation. Clearly, these F-ratios are very large, and they reject the hypothesis that the instruments are weak. Moreover, the coefficients of $\alpha_2 - 1$ in the wage equation and $\beta_2 - 1$ in the health equation are nowhere near 0. The values of $\alpha_2 - 1$ are all -0.40 in the first-stage wage equation ($\alpha_2 = 0.60$) and range from -0.45 to -0.71 in the first-stage health equation (β_2 ranges from 0.29 to 0.55) that correspond to the F-ratios in Table 3. These values are almost the same in the first stage wage regression and health regressions that correspond to the F-ratios in Table 4. In addition, as shown in Table 1, the within-person variation in our outcomes is at least as large as the between-person variation in almost all cases. In short, there is little evidence that our estimates would be

improved by estimating the level equation. Since that procedure would greatly increase the number of instruments, we do not pursue it. Finally, we note that the key coefficients of interest—the cross effect of past health on the current wage (α_1) and the cross effect of the past wage on current health (β_1) are very similar in the two-stage least squares model and in the Arellano-Bond mode with up to three lags of the wage and health as instruments.

Turning to the estimated health equations in Table 3, one sees that the coefficients of β_1 never are significant. In other words, we have no evidence that a change in last period's wage has an effect on health in this period. Why might that be the case? One explanation is that they suggest effects that go in opposite directions in the human capital and compensating wage differential models and that could offset each other. For example, in the human capital model, the positive effect of the wage on health could be small or nonexistent if the share of the money price of medical care and other goods purchased in the market in the marginal cost of health production is small. In that case, the marginal rate of return to an investment in health would be insignificant and might be swamped by substitution effects towards goods-intensive commodities in a mixed investment-consumption framework. Alternatively, positive effects in the human capital model might be offset by negative realizations of current period reductions in health by persons who accepted a relatively high wage in a previous period to accept a job with a higher than average expected health risk.

In Table 4, one sees that two of the five coefficients of α_1 are statistically significant. These are the ones associated with self-rated health and with the number of times a respondent was injured or ill and not treated. Keep in mind that the self-rated health measure is a positive correlate of better health so that both the negative coefficient of that variable and the positive coefficient of the frequency of untreated injury or illness indicate that a reduction in past-year

health is associated with an increase in the current-year wage. This result is not consistent with the notion that an increase in health after the completion of formal schooling should increase further investments in knowledge via on-the-job training. It is consistent with one of our extensions of the compensating wage differential model in which a large amount of effort in one period is required to obtain promotions and the wage increases that accompany them in subsequent periods. That effort may cause reductions in health and to a negative effect of health in the previous period on the current period wage. The result also is consistent with a model in which on-the-job training is a joint product of hours of work and competes for scarce time with investments in health.¹²

One explanation for why we find the results for injured or ill and not treated and not for injured or ill and treated is that those treated contain two groups of individuals. The first group has serious injuries that force them to miss work for some amount of time. This would cause lower wage rates, possibly because they invest less in on-the-job training or have lower levels of effort. The second group does not miss work and like the untreated group has higher levels of effort that lead to higher wages. Note that while we employ a continuously employed sample, it is not limited to workers who worked the same number of hours per year or the same number of days or weeks per year in each period.

While we find some evidence that a reduction in health leads to an increase in the wage, that evidence is limited to continuously employed workers. It might be weakened or even reversed if we did not limit the sample to that group. For example, a worker who is forced to leave the labor force due to poor health and then returns a year or two later may have a lower

¹² In both Tables 3 and 4, the overidentification restrictions are accepted, and there is no evidence of second-order serial correlation in the residuals. First-order serial correlation in the difference equation is to be expected if, for example, u_{it} and u_{is} ($s \neq t$) are uncorrelated since the disturbance in the first difference equation at times t and $t-1$ share a common term (u_{it-1}).

wage than an otherwise identical continuously employed worker due to a loss of experience and on-the-job investment.

In Tables 5 and 6, we examine how the negative cross effects of past health on the current wage vary by groups classified by education, gender, occupation, and race/ethnicity. We focus on the two significant effects for the population at large because there are no cross effects of the lagged wage on current health for these groups. In addition, the only significant lagged health effects pertain to those involving self-rated health and the frequency of untreated illness or injury.¹³

In Table 5, we compare individuals with a high school education or less to those with some college or more, males versus females, and workers in physically taxing versus mentally taxing occupations. Our classification of occupations into physically or mentally demanding is contained in Table A1 in the appendix. While the self-rated health status effect is not significant for either education group, it is bigger for the more educated group, bigger for that group than for the full sample, and significant at $p < 0.16$. On the other hand, the coefficient of the number of times injured or ill and not treated, while positive and significant for both groups, is larger for the less educated than for the more educated. One explanation of these results is that the less educated tend to be employed in more risky and physically demanding blue-collar occupations, while the more educated tend to be found in mentally demanding white-collar occupations. Hence, higher levels of effort in a prior period require more physical labor on the part of the less educated and result in untreated injuries or accidents in that group. On the other hand, these higher levels make more mental demands on the more educated and result in reductions in their self-rated health. In either case, compensating wage increases are realized in subsequent periods.

¹³ The estimates in Tables 5 and 6 include the lag of the first difference of the wage, but its coefficients are not shown.

A similar picture emerges when females are compared to males. The four health coefficients are negative and significant for both groups. But the self-rated health effect is larger for females than for males, while the untreated injury or illness effect is larger for males. This is consistent with greater prevalence of males in blue collar occupations.

The results by occupation give a considerable amount of credence to our interpretation. The self-rated health effect is not significant for either occupation group. But it is bigger for the one that we classify as mentally demanding, bigger for that group than for the full sample, and significant at $p < 0.12$ despite a sample size that is smaller than any of the others in Table 5. On the other hand, the untreated injury effect is larger in the physically demanding occupations than in the mentally demanding ones or in any other group in Table 5 or in the full sample and is significant at $p < 0.01$. A caveat here is that our classification of occupations into physically or mentally demanding is somewhat arbitrary.

In Table 6, we compare white non-Hispanics, black non-Hispanics, and Hispanics.¹⁴ The self-rated health coefficient is negative and significant for whites but not for the other two groups. Moreover, the magnitude of this coefficient is almost two and a half times as large as it is in the pooled sample. While all three coefficients of untreated illness or injury measure are positive and significant, they are bigger for black non-Hispanics and Hispanics than for whites. While the black coefficient is estimated imprecisely, the Hispanic coefficient is significant, twice as large as the white coefficient, and almost 70 percent larger than the black coefficient. Again, these results are consistent with occupational patterns in which whites are more likely to have white-collar jobs than minorities. The larger untreated illness and injury effect for Hispanics compared to blacks also is consistent with surveys in which Hispanics are more likely to believe

¹⁴ We include the very small percentage of the sample who are in the other race, non-Hispanic category with whites. Exclusion of them from the white sample does not alter our results.

in the efficacy of hard work than the population at large (for example, Taylor, Lopez, Martínez, and Velasco 2012).

VI. Discussion

We uncover a causal relationship between two of five measures of health and the wage in which a reduction in health leads to an increase in the wage rate in a panel of U.S. young adults who had completed their formal schooling by 2006 and were continuously employed from that year through 2011. There is no evidence of a causal relationship running from the wage rate to health in this panel. The former result highlights the multidimensional nature of health. It is consistent with an extension of the compensating wage differential model in which a large amount of effort in one period is required to obtain promotions and the wage increases that accompany them in subsequent periods. That effort may cause reductions in health and to a negative effect of health in the previous period on the current period wage. In this framework, employees have imperfect information about the effort requirements of a particular job when they are hired, and employers have imperfect information about the amount of effort new hirers are willing to exert. The result also is consistent with a model in which investments in career advancement compete with investments in health for time—the ultimate scarce resource. The latter result suggests that forces that go in opposite directions in the human capital and compensating wage differential models may offset each other.

A good deal of caution is required in interpreting our findings and in extrapolating them to the population at large. Clearly, the results pertain to a selected sample. The panel members were at the early stages of their working careers during the period at issue and were continuously employed during the Great Recession. The realization that many of their colleagues were unemployed or could not find jobs may have caused them to increase their work effort, which

resulted in reductions in health but led to subsequent wage increases. This may be one subtle factor in the findings in some studies that positive correlates of health rise in a recession (for example, Ruhm 2000, 2003, 2005; Cutler, Huang, and Lleras-Muney 2016). Another consideration is that the interpretation of our main result—that reductions in health cause increases in the wage because these increases are associated with high levels of past effort—needs to be investigated in detail.

We view the last item as a challenging one on an agenda for future research. Work effort surely is related to hours of work, but the latter is not a perfect correlate of the former. In addition, effort may have different effects in different industries and occupations and on different measures of health as our results suggest. Finally, effort and hours of work surely are endogenous variables. Hence, in the short and intermediate runs, priority should be given to obtaining estimates in a longer panel than the one we have employed. That panel should contain persons of all ages and should have the ability to examine how estimates differ in recessions compared to expansions.

References

- Arellano, Manuel. 2003. *Panel Data Econometrics*. New York: Oxford University Press.
- Arellano, Manuel, and Stephen Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58(2): 277-297.
- Arellano, Manuel, and Olympia Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics* 68(1): 29-51.
- Baltagi, Badi H. 2008. *Econometric Analysis of Panel Data*. Fourth Edition. Chichester, United Kingdom: Wiley.
- Ben-Porath, Yoram. 1967. "The Production of Human Capital and the Life Cycle of Earnings." *Journal of Political Economy* 75(4, part 1): 352-365.
- Blundell, Richard, and Stephen Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87(1): 115-143.
- Cutler, David M, Wei Huang, and Adriana Lleras Muney. 2016. "Economic Conditions and Mortality: Evidence from 200 Years of Data." Cambridge, MA: National Bureau of Economic Research Working Paper No. 22690.
- Ehrlich, Isaac, and Hiroyuki Chuma. 1990. "A Model of the Demand for Longevity and the Value of Life Extension." *Journal of Political Economy* 98(4): 761-782.
- Ekeland, Ivar, James J. Heckman, and Lars Nesheim. 2004. "Identification and Estimation of Hedonic Models." *Journal of Political Economy* 112(1, pt. 2): S60-S109.
- Fuchs, Victor R. 1982. "Time Preference and Health: An Exploratory Study." In *Economic Aspects of Health*, ed. Victor R. Fuchs. Chicago: University of Chicago Press: 93-120.

- Galama, Titus, and Hans van Kippersluis. 2016. "A Theory of Education, Health and Longevity." Presented at a conference entitled "Human Capital and Health Behavior." Gothenburg University, Sweden, May 19-20.
- Granger, Clive W. J. 1969. "Investigating Causal Relationships by Econometric Models and Cross-Spectral Methods." *Econometrica* 37(3): 424-438.
- Grossman, Michael. 1972a. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80(2): 223-255.
- Grossman, Michael. 1972b. *The Demand for Health: A Theoretical and Empirical Investigation*. New York: Columbia University Press for the National Bureau of Economic Research. Re-issued with a Forward from Björn Lindgren by Columbia University Press, 2017.
- Grossman, Michael. 1976. "The Correlation between Health and Schooling." In *Household Production and Consumption*, ed. Nestor E. Terleckyj. Studies in Income and Wealth, Volume 40, by the Conference on Research in Income and Wealth. New York: Columbia University Press for the National Bureau of Economic Research: 147-211.
- Grossman, Michael. 2000. "The Human Capital Model. In *Handbook of Health Economics*, Volume 1A, ed. Anthony J. Culyer and Joseph P. Newhouse. Amsterdam: North-Holland, Elsevier Science: 347-408.
- Grossman, Michael. 2006. "Education and Nonmarket Outcomes." In *Handbook of the Economics of Education*, Volume 1, ed. Eric Hanushek and Finis Welch. Amsterdam: North-Holland, Elsevier Science: 577-633.
- Grossman, Michael. 2015. "The Relationship between Health and Schooling: What's New?" *Nordic Journal of Health Economics* 3(1): 7-17.

- Grossman, Michael. 2017. *Determinants of Health: An Economic Perspective*. New York: Columbia University Press.
- Grossman, Michael, and Lee Benham. 1974. "Health, Hours and Wages." In *The Economics of Health and Medical Care*, ed. Mark Perlman. London: The Macmillan Press: 205-233.
- Heckman, James J., Rosa L. Matzkin, and Lars Nesheim. 2010. "Nonparametric Identification and Estimation of Nonadditive Hedonic Models." *Econometrica* 78(5): 1569-1591.
- Inoue, Makiko, and Megan Specia. 2017. "Japan Confronts Latest Death From Overwork." *New York Times* October 6: A4.
- Kniesner, Thomas J., W. Kip Viscusi, Christopher Woock, and James P. Ziliak. 2012. "The Value of a Statistical Life: Evidence from Panel Data." *The Review of Economics and Statistics* 94(1): 74-87.
- Lee, Lung-Fei. 1982, "Health and the Wage: A Simultaneous Equation Model with Multiple Discrete Indicators." *International Economic Review* 23(1): 199-221.
- Mincer, Jacob. 1974. *Schooling, Experience, and Earnings*. New York: Columbia University Press for the National Bureau of Economic Research.
- Roodman, David. 2009. "How to do xtabond2: An Introduction to Difference and System GMM in Stata." *The Stata Journal* 9(1): 86-136.
- Rosen, Sherwin. 1972. "Learning and Experience in the Labor Market." *Journal of Human Resources* 7(3): 326-342.
- Rosen, Sherwin. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy* 82(1): 34-55.

- Rosen, Sherwin. 1986. "The Theory of Equalizing Differences." In *Handbook of Labor Economics*, Volume 1 ed. Orley C. Ashenfelter and Richard Layard. Amsterdam: North-Holland, Elsevier: 641-692.
- Ruhm, Christopher J. 2000. "Are Recessions Good for Your Health?" *The Quarterly Journal of Economics* 115(2): 617–650.
- Ruhm, Christopher J. 2003. "Good Times Make You Sick." *Journal of Health Economics* 22(4): 637–658.
- Ruhm, Christopher J. 2005. "Healthy Living in Hard Times." *Journal of Health Economics* 24(2): 341–363.
- Schreier, Jason. 2017. "The 'Crunch' Problem in the Gaming Industry." *New York Times* October 26: A29.
- Smith, Adam. 1937. *An Inquiry into the Causes and Consequences of the Wealth of Nations*, ed. with an Introduction by Max Lerner. New York: Random House.
- Taylor, Paul, Mark Hugo Lopez, Jessica Martínez, and Gabriel Velasco. 2012. "Hispanic Trends: The American Experience." Pew Research Center, April 4, <http://www.pewhispanic.org/2012/04/04/iii-the-american-experience/>, last accessed October 17, 2017.
- Viscusi, W. Kip. 1993. "The Value of Risks to Life and Health." *Journal of Economic Literature* 31(4): 1912-1946.
- Viscusi, W. Kip. 2014. "The Value of Individual and Societal Risks to Life and Health." In *Handbook of the Economics of Risk and Uncertainty*, Volume 1 ed. Mark Machina and W. Kip Viscusi. Amsterdam: North-Holland, Elsevier Science: 385-450.

Table 1: Means and Within and Between S.D. of Endogenously Treated Variables

Dependent Variable	Mean	S.D. Overall	S.D. Between	S.D. Within	Person-years	Respondents
Log Wage	2.66	0.62	0.52	0.34	11325	2497
Self-Rated Health	1.73	0.45	0.36	0.27	11324	2497
Limited in the Kind of Work	0.02	0.16	0.11	0.12	11315	2497
Limited in the Amount of Work	0.02	0.14	0.10	0.10	11319	2497
# of Time Injured or Ill and not Treated by a Doctor or Nurse	0.74	1.19	0.84	0.86	11312	2497
# of Times Injured or Ill and Treated by a Doctor or Nurse	0.51	0.97	0.67	0.71	11322	2497

Note: Sample includes respondents from 2007 to 2011 who have completed education and who are not missing a wave and are included in regressions in Table 4. Results are almost identical when the sample is based on the regressions in Table 3. Wages are based on current full-time or part-time jobs. Self-rated health is based on the question "In general, how is your health? Excellent, Very Good, Good, Fair, or Poor?" scaled by the predicted work-loss days from NHIS which has the same question. Specifically, each category is scaled as the natural log of each category's predicted work-loss days relative to the poor category [e.g. $\ln(\text{predicted poor work-loss days}/\text{predicted Excellent work-loss days})$], # of times injured or ill and not treated, and # of times injured or ill and treated both range from 0 to 4+, where 4+ is a top code and is set equal to 4.

Table 2: Sample Characteristic Mean and S.D.

Variable	Mean	S.D.	Minimum	Maximum
White	0.52	0.50	0.00	1
Black, Non-Hispanic	0.22	0.41	0.00	1
Hispanic	0.23	0.42	0.00	1
Other Race, Non-Hispanic	0.03	0.18	0.00	1
Female	0.43	0.49	0.00	1
High School or Less	0.56	0.50	0.00	1
Some College, Less than Bachelor's Degree	0.21	0.41	0.00	1
Bachelor's Degree or Higher	0.23	0.42	0.00	1
Age	27.04	1.96	22	32
Potential Experience in Years	6.21	2.83	0.01	14.00
Wave=2008	0.25	0.43	0.00	1.00
Wave=2009	0.27	0.44	0.00	1.00
Wave=2010	0.25	0.43	0.00	1.00
Wave=2011	0.23	0.42	0.00	1.00
Married and Spouse Present	0.34	0.47	0.00	1.00
Own Income Excluding Earnings	1294.15	8319.21	-6900	188417
Spouse's Income	14157.26	22880.66	0.00	250000
Number of Kids	0.89	1.1	0.00	7

Note: N=11,325

Table 3: Arellano-Bond Estimates of the Effects of Last Year's Health and Wage on This Year's Health

	Self-Rated Health	Health Limits Kind of Work	Health Limits Amount of work	Number of Times injured or Ill and not Treated	Number of Times Injured or Ill and Treated
Lag Health	0.0347 (0.0280)	0.0519 (0.0508)	-0.00650 (0.0517)	0.0709*** (0.0223)	0.142*** (0.0251)
Lag Wage	-0.00994 (0.0207)	-0.00217 (0.0104)	0.0113 (0.00975)	0.0148 (0.0498)	0.000404 (0.0454)
N	7121	7105	7108	7092	7115
Hansen Overidentification P-Value	0.148	0.303	0.393	0.0950	0.838
AB test for AR(2) P-Value	0.223	0.637	0.490	0.733	0.344
First Stage Wage Excluded Instruments F-Stat	96.05	94.49	93.67	95.41	94.45
First Stage Health Excluded Instrument F-Stat	531.2	197.6	163.5	851.2	663.6

Note: * p<.1, ** p<.05, *** p<.01. Estimates based on Arellano-Bond using difference equations only. S.E. is clustered at the individual level. We use a maximum lag length of 3, but results are not sensitive to lag length. Reported first stage F-statistics are based on first stage regressions that are exactly identified with the second lag of the level of health and log wages used to predict the lag difference of health and log wages. Exogenous controls include age and wave dummies, although results are not sensitive to inclusion or exclusion of age. They are also not sensitive to inclusion or exclusion of marital status, number of kids, own income excluding earnings, and spouses' income, treated exogenously.

Table 4: Arellano-Bond Estimates of the Effects of Last Year's Health and Wage on This Year's Wage

	Self-Rated Health	Health Limits Kind of Work	Health Limits Amount of Work	Number of Times Injured or Ill and not Treated	Number of Times Injured or Ill and Treated
Lag Wage	0.0955*** (0.0355)	0.0955*** (0.0351)	0.0928*** (0.0358)	0.0931*** (0.0350)	0.0959*** (0.0351)
Lag Health	-0.0479* (0.0289)	-0.00231 (0.0576)	-0.0276 (0.0723)	0.0209** (0.00818)	0.000995 (0.00959)
N	6331	6323	6324	6318	6331
Hansen Overidentification P-Value	0.727	0.793	0.554	0.514	0.736
AB test for AR(2) P-Value	0.383	0.385	0.378	0.354	0.386
First Stage Wage Excluded Instrument F-Stat	84.06	82.02	81.12	83.04	82.36
First Stage Health Excluded Instrument F-Stat	481.0	179.5	154.3	749.5	605.8

Note: * p<.1, ** p<.05, *** p<.01. Estimates based on Arellano-Bond using difference equations only. S.E. is clustered at the individual level. We use a maximum lag length of 3, but results are not sensitive to lag length. Reported first stage wage F-statistics are based on first stage regressions that are exactly identified with the second lag of the level of health and log wages used to predict the lag difference of health and log wages. Exogenous controls include potential experience and wave dummies, although results are not sensitive to inclusion or exclusion of potential experience. They are also not sensitive to inclusion or exclusion of marital status, number of kids, own income excluding earnings', and spouses' income, treated exogenously.

Table 5: Arellano-Bond Estimates of the effect of Last Year's Health on this Year's Wage by Education and Gender

	Self-Rated Health						Number of Times Injured or Ill and not Treated					
	High School or Less	Some College or More	Male	Female	Physical Occ.	Mental Occ.	High School or Less	Some College or More	Male	Female	Physical Occ.	Mental Occ.
Lag Health	-0.0239 (0.0388)	-0.056 (0.0400)	-0.0264 (0.0419)	-0.0815** (0.0389)	-0.0379 (0.0366)	-0.0724 (0.0474)	0.0253** (0.0121)	0.0176* (0.0101)	0.0238* (0.0122)	0.0182* (0.0105)	0.0301*** (0.0112)	0.0053 (0.0101)
N	3468	2863	3657	2674	3969	1996	3459	2859	3650	2668	3961	1991

Note: * p<.1, ** p<.05, *** p<.01. Estimates based on Arellano-Bond using difference equations only. Coefficients of lag wage not shown. S.E. is clustered at the individual level. We use a maximum lag length of 3, but results are not sensitive to lag length. Exogenous controls include potential experience and wave dummies, although results are not sensitive to inclusion or exclusion of potential experience. They are also not sensitive to inclusion or exclusion of marital status, number of kids, own income excluding earnings, and spouses' income, treated exogenously.

Table 6: Arellano-Bond Estimates of the Effect of Last year's Health on This Year's Wage by Race-Ethnicity

	Self-Rated Health			Number of Times Injured or Ill and not Treated		
	White	Black	Hispanic	White	Black	Hispanic
Lag Health	-0.116*** (0.0422)	-0.0292 (0.0572)	0.0474 (0.0484)	0.0170* (0.00985)	0.0210 (0.0224)	0.0352* (0.0197)
N	3546	1336	1449	3459	1334	1448

Note: * p<.1, ** p<.05, *** p<.01. Estimates based on Arellano-Bond using difference equations only. Coefficients of lag wage not shown. S.E. is clustered at the individual level. We use a maximum lag length of 3, but results are not sensitive to lag length. Exogenous controls include potential experience and wave dummies, although results are not sensitive to inclusion or exclusion of potential experience. They are also not sensitive to inclusion or exclusion of marital status, number of kids, own income excluding earnings, and spouses' income, treated exogenously.

Appendix

Appendix Table 1: Occupation Classification into Mentally and Physically Intensive Categories

Occupation Code: Broad Classification Category	Mental	Physical
10 TO 430: EXECUTIVE, ADMINISTRATIVE AND MANAGERIAL	X	
500 TO 950: MANAGEMENT RELATED	X	
1000 TO 1240: MATHEMATICAL AND COMPUTER SCIENTISTS	X	
1300 TO 1530: ENGINEERS, ARCHITECTS, AND SURVEYORS	X	
1540 TO 1560: ENGINEERING AND RELATED TECHNICIANS	X	
1600 TO 1760: PHYSICAL SCIENTISTS	X	
1800 TO 1860: SOCIAL SCIENTISTS AND RELATED WORKERS	X	
1900 TO 1960: LIFE, PHYSICAL, AND SOCIAL SCIENCE TECHNICIANS	X	
2000 TO 2060: COUNSELORS, SOCIAL, AND RELIGIOUS WORKERS	X	
2100 TO 2150: LAWYERS, JUDGES, AND LEGAL SUPPORT WORKERS	X	
2200 TO 2340: TEACHERS	X	
2400 TO 2550: EDUCATION, TRAINING, AND LIBRARY WORKERS	X	
2600 TO 2760: ENTERTAINERS AND PERFORMERS, SPORTS AND RELATED WORKERS		
2800 TO 2960: MEDIA AND COMMUNICATION WORKERS	X	
3000 TO 3260: HEALTH DIAGNOSIS AND TREATING PRACTITIONERS	X	
3300 TO 3650: HEALTH CARE TECHNICAL AND SUPPORT		
3700 TO 3950: PROTECTIVE SERVICE		X
4000 TO 4160: FOOD PREPARATIONS AND SERVING RELATED		X
4200 TO 4250: CLEANING AND BUILDING SERVICE		X
4300 TO 4430: ENTERTAINMENT ATTENDANTS AND RELATED WORKERS		X
4460: FUNERAL RELATED OCCUPATIONS		
4500 TO 4650: PERSONAL CARE AND SERVICE WORKERS		X
4700 TO 4960: SALES AND RELATED WORKERS	X	
5000 TO 5930: OFFICE AND ADMINISTRATIVE SUPPORT WORKERS		X
6000 TO 6130: FARMING, FISHING, AND FORESTRY		X
6200 TO 6940: CONSTRUCTION TRADES AND EXTRACTION WORKERS		X
7000 TO 7620: INSTALLATION, MAINTENANCE, AND REPAIR WORKERS		X
7700 TO 7750: PRODUCTION AND OPERATING WORKERS		X
7800 TO 7850: FOOD PREPARATION		X
7900 TO 8960: SETTER, OPERATORS, AND TENDERS		X
9000 TO 9750: TRANSPORTATION AND MATERIAL MOVING WORKERS		X

Note: Unmarked categories are left out of the occupation splits in Table 5 because it is not obvious how to classify them. Workers in the unmarked categories account for a very small number of observations.