Can Wealth Buy Health?
A Model of Pecuniary and Non-Pecuniary Investments in Health*

Panos Margaris† Johanna Wallenius‡

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Abstract

In this paper we develop and estimate a life cycle model that features pecuniary and non-pecuniary investments in health, along with a cognitive ability gradient associated with said investments, in order to rationalize the socioeconomic gradients in health and life expectancy in the United States. Agents accumulate health capital, which affects the level of utility, labor productivity, the distribution of medical spending shocks and life expectancy. We find that the cognitive ability gradient to health investments and the differences in lifetime income account for the lion's share of the observed life expectancy gap. Providing universal health insurance coverage has heterogeneous effects, depending on the progressivity of the financing mechanism, and at best results in a modest decrease in the life expectancy gap.

JEL Classification: E21, D31, D15, I14, I31

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†Department of Economics, Concordia University, panos.margaris@concordia.ca

‡Department of Economics, Stockholm School of Economics johanna.wallenius@hhs.se

1 Introduction

The gap in life expectancy at age 25 between college graduates and high school graduates in the U.S. is 5.5 years for men. In this paper, we study the underlying sources of this striking inequality and the implications thereof for government policies aimed at improving access to healthcare, such as a Medicare-for-all type policy. To do so, we estimate a heterogeneous agent, life cycle model where individuals make both pecuniary and non-pecuniary investments in health.

Using data from the Medical Expenditure Panel Survey (MEPS), we document that, on average, individuals across the educational gradient exhibit similar life cycle profiles of healthcare spending. However, the average conceals a substantial degree of heterogeneity. High school graduates spend less on medical services and are less likely to use screening and other preventive medical services than college graduates, for every level of health. The reason for the lack of an educational gradient in the average medical spending is the educational gradient in health. High school graduates are more likely to be in poor health, resulting in medical spending that is on par with their healthier, more educated counterparts. To illustrate, a 45-year old individual with poor health spends more than five times more on healthcare compared to an individual of the same age with excellent health.

Furthermore, we document substantial variation in health insurance coverage across the different levels of educational attainment. College graduates are more likely to be employed in occupations that offer group health insurance (GHI) plans, which offer lower premiums, better coinsurance rates and are non-discriminatory with respect to pre-existing conditions, and less likely to be uninsured. Hence, highly educated individuals not only have more pecuniary resources to invest in their health, but also face a lower effective price.

However, differences in access to resources and health insurance coverage alone cannot fully account for the socioeconomic gradient in life expectancy. Mokdad et al. (2004) document that nearly 50% of all deaths in the U.S. are attributed to modifiable behavioral factors. This is evidenced by the existence and persistence of the life expectancy gradient even in countries with equal (and in some cases free) access to healthcare[1]. These behaviors can be positive

[1]For example, Bueren et al. (2018) document a very similar life expectancy gap for 50 year old males in the U.S. and the U.K., despite the U.K. having universal health insurance coverage which is mostly free at the point of service.

(e.g., healthy diet, exercise, wearing a seatbelt) or negative (e.g., smoking or heavy drinking). Here, we focus on the positive, and specifically on the time investment in health promoting activities, as in the seminal paper of Grossman (1972). We use data from the American Time Use Survey (ATUS) to estimate non-pecuniary investments in health across the different educational levels. Consistent with previous studies, we find that highly educated individuals are more likely to spend time on health promoting activities, such as time spent on doctor's visits for preventive and screening services, sports and exercise, self-care and personal care compared to low educated individuals[2]. Some of these health behaviors are indeed influenced by pecuniary resources and health insurance coverage. However, Cutler and Lleras-Muney (2010) show that income and effective price differences account for at most 30% of the educational gradient in health behaviors. Even if medical care is free, the gradient in preventive healthcare utilization still persists (Newhouse, 1993).

Furthermore, education affects the effectiveness of pecuniary and non-pecuniary investments in health. More educated individuals are more likely to comply with treatments which rely on complex technologies and lifestyle changes such as HIV and diabetes (Goldman and Smith, 2002). Using changes in compulsory schooling laws to control for confounding factors, Lleras-Muney (2005) finds a significant effect of schooling on mortality . Gilleskie and Harrison (1998) show that, controlling for health insurance status, preventive care utilization and behavioral choices, an additional year of schooling reduces the probability of being in poor health by 19.65% for males, due to improved productive and allocative efficiency of health investments. Thus, the difference in the effectiveness of pecuniary and non-pecuniary investments over education can be large.

We develop a life cycle model to account for these salient features regarding the socioeconomic gradients in health and life expectancy. In the model, health is a stock that depreciates stochastically over age. Agents can invest in health through preventive medical spending and time spent in health promoting activities. Health affects life expectancy, labor productivity, the level of utility, and the distribution of exogenous curative medical spending shocks. Agents are ex-ante heterogeneous with respect to their educational attainment, which determines their labor productivity, the probability of being offered GHI, the effectiveness of pecuniary

[2]Throughout the paper we refer to individuals with at most a high school degree as high school graduates and individuals with at least some years of college as college graduates.

and non-pecuniary investments in health, and their initial level of health.

We calibrate the model to the U.S. economy prior to the full implementation of the Affordable Care Act (ACA), and incorporate key features of the U.S. health insurance market and means-tested welfare programs. Agents are offered GHI with a probability conditional on their level of education, and everyone can purchase private health insurance (PHI) with a premium that is determined by their level of health. Agents are enrolled in Medicaid if their income is below the Medicaid threshold or the medical spending shock is larger than their disposable income. In addition, the government guarantees a minimum level of consumption. Medicare enrollment starts at age 65.

The model successfully reproduces the age profiles for pecuniary and non-pecuniary investments in health, and generates the observed education gradients in life expectancy and health. In our model, highly educated individuals spend more pecuniary and non-pecuniary resources on health, and are on average healthier and live longer than their less educated counterparts. There are four drivers of this. First, highly educated individuals have on average higher income and better health insurance options. Second, pecuniary and non-pecuniary investments in health are more effective for college graduates because of higher cognitive ability. Third, since agents are risk averse, it is optimal for high income individuals to sacrifice a larger share of current consumption in order to increase their level of utility and enjoy more periods of future consumption. Fourth, college graduates enter the economy with better health compared to high school graduates, which reflects the socioeconomic gradient in childhood health, and has persistent effects in our model.

Our analysis suggests that the largest contributing factors to the observed socioeconomic gradients in health and life expectancy are the gradient in the effectiveness of health investments as well as overall income differences, with unequal access to healthcare playing only a minor role. Eliminating the effectiveness and labor productivity gradients reduces the life expectancy gap by 3.3 years and 0.9 years respectively. The effect of the education gradient in the effectiveness of health investments on life expectancy is large, but falls within the range of empirical estimates of the effects of schooling on mortality[3]. In contrast, eliminating the unequal access

[3]In our counterfactual simulations, an additional year of schooling for the low educated increases life expectancy by one year. This is below the empirical estimates of Lleras-Muney (2005), who uses changes in compulsory schooling laws as an instrument for education.

to health insurance reduces the life expectancy gap by at most 0.3 years. We find that, given the social provisions in place, namely Medicaid and the minimum level of consumption, and the willingness of low educated individuals to pay for healthcare services, unequal access to private health insurance does little to exacerbate the gradients in health and life expectancy.

With our Medicare-for-all type policy, the government extends public health insurance coverage to all agents and offers a uniform coinsurance rate that covers the same fraction of total medical spending for everyone. In order to keep the policy budget neutral, we consider four different funding mechanism to compensate for the resulting increase in government spending: (i) increase in the Medicare premium, (ii) increase in the level of the income tax, (iii) increase in the income tax progressivity, and (iv) decrease in the average coinsurance rate. We find that only when financing the Medicare expansion through an increase in the progressivity of the income tax schedule do we observe both a narrowing of the life expectancy gap and an increase in welfare.

There is a sizeable literature that studies medical spending either as an exogenous process that affects savings (e.g., Hubbard, Skinner and Zeldes (1995), De Nardi, French and Jones (2010), Kopecky and Koreshkova (2014)), labor supply (Rust and Phelan (1997), French (2005), French and Jones (2011)) or health insurance decisions (Zhao (2017) and Jeske and Kitao (2009)) or as a choice variable that affects life expectancy and quality of life ((Hall and Jones, 2007) and Zhao (2014)) or labor income (Prados (2017) and Halliday et al. (2017)). Similar to Ozkan (2017), we decompose medical spending into both a choice variable in the form of preventive healthcare spending and a curative medical spending shock with an endogenous distribution conditional on the health of the individual. To the best of our knowledge, we are the first to study both pecuniary and non-pecuniary investments in health in a life cycle model where agents have heterogeneous cognitive ability in order to rationalize the socioeconomic gradients in health and life expectancy. Health behaviors and non-pecuniary investment in health across the educational gradient have been studied in the empirical literature (for example, Cutler and Lleras-Muney (2010), Morrill et al. (2016) and Bij-awaard et al. (2015)) and have been found to explain a substantial fraction of the observed inequality in health and life expectancy. Further, we introduce the concept of cognitive ability, which affects the productivity of pecuniary and non-pecuniary investments in health. Consistent with this branch of the literature, we find that agents' incentives to invest in their level of health is significantly affected by their cognitive ability.

The rest of the paper is organized as follows. Section 2 describes the stylized facts of medical spending, health insurance and non-pecuniary investment in health. Section 3 introduces the model. Section 4 describes the parameterization of the model, while Section 5 discusses the fit of the model to the data. Section 6 presents the decomposition of the life expectancy gap. Section 7 discusses the quantitative results of universal health insurance coverage and Section 8 concludes.

2 Stylized Facts

In this section we present stylized facts with respect to health, survival, medical spending, health insurance and time use for different socioeconomic groups of males in the United States before the full implementation of the Affordable Care Act. In particular, we focus on differences over education and age. These salient patterns motivate many of our modeling choices in order to rationalize the gradients in health and life expectancy, and are instrumental in assessing policy reforms.

2.1 Data and Methodology

We use data on medical spending, preventive care utilization, medical conditions and health insurance from the Medical Expenditure Survey (MEPS), time use data from the American Time Use Survey (ATUS), labor income and labor force participation data from the Panel Study of Income Dynamics (PSID), disability benefits data from the American Community Service (ACS) and mortality data from the Center of Disease Control and Prevention (CDC). We define two education categories, low and high educated. Low educated includes high school dropouts and high school graduates and high includes those with some college, college graduates or more. We group individuals into 6 age intervals: 25-34, 35-44,..., 65-74 and 75 and older.

We estimate the mortality hazard using data from the CDC, which provides detailed data on mortality by age, education and cause of death, and population estimates from the ACS. The mortality hazard is estimated as the ratio of the total number of deaths over the total population by age and education. We consider only health-related mortality, excluding homicides and accidents from our death estimates, since we want to focus on the effect of the gradient in health on the life expectancy gap.

We construct measures for real medical spending by age and education using total healthcare expenditure adjusted for inflation in medical services using the Medical Price Index (MPI). This includes both out-of-pocket payments and payments from public and private institutions. Preventive care utilization by education and age is estimated using MEPS and ATUS data.

Non-pecuniary investment is defined as time spent in health promoting activities, as reported in the ATUS. We focus on three categories of health-related activities: (i) sports and exercise, (ii) utilizing medical services, and (iii) personal care. Physical exercise is well established as an important health factor (Haskell et al., 2007). An increasingly sedentary lifestyle is associated with the rise in the prevalence of obesity, which has adverse effects on life expectancy and health (Griffith, Lluberas and Lührmann, 2016). In our time use measure, we also include the time spent utilizing, traveling and waiting for medical services. Finally, from the personal care category we include time spent on personal healthcare, personal health emergencies and general self-care, but exclude sleeping.

Throughout the paper, we use the self-reported level of health as our measure of health status. We consider this measure to be appropriate in the context of our model, since health enters the utility function directly and the perceived level of health has an effect on pecuniary and non-pecuniary investment. In addition, Cutler and Lleras-Muney (2010) note that there is no documented bias of self-reported health by educational attainment that could potentially affect our results.

2.2 Life Expectancy and Health

The striking life expectancy gap is the result of a persistent and increasing gradient in health and the probability of survival throughout the life cycle[4]. Figure 1a shows that, even excluding mortality by homicides and accidents which is a substantial mortality risk for young men, the probability of survival is lower for young high school graduates compared to college

[4]It is important to note that the gradients in health and the conditional probability of survival tend to be underestimated due to survival bias. The gradient in the mortality risk puts higher pressure on unhealthy individuals and, on average, healthier individuals survive to older ages. Survival bias is more evident in measures of average health, where we observe an improvement for older high school graduates.

graduates. The differences in the probability of survival stem from differences in the average level of self-reported health (1b), which is a good predictor of mortality (Burström, 2001).

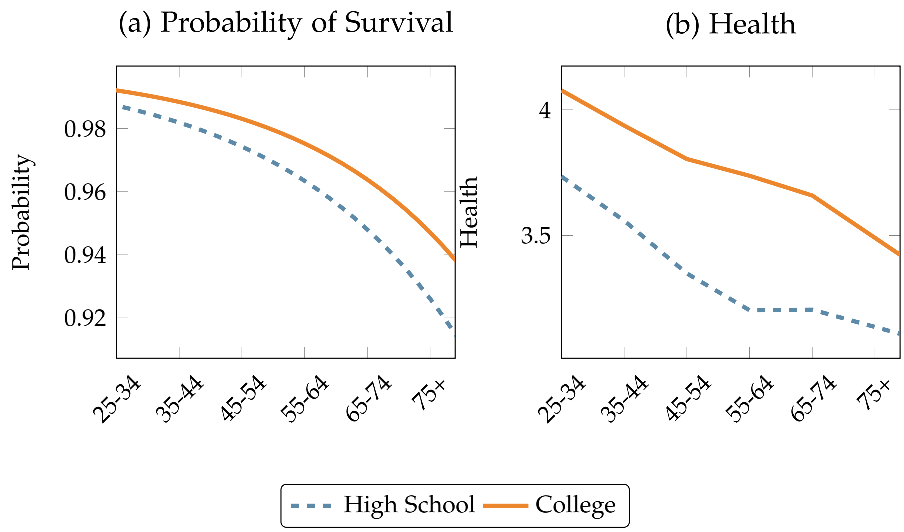

Figure 1: Health and Conditional Probability of Survival by Education and Age

Notes: Figure (a) shows the conditional probability of survival by education and age, excluding homicides and accidents. Figure (b) shows average health by age and education, where 5 corresponds to "Excellent" and 1 to "Poor" health.

Source: MEPS, CDC and ACS, 2000-13.

Differences in health in young adults, adolescents and even fetuses can have persistent effects on health later in life (Almond and Currie, 2011). Already at age 25, high school graduates exhibit much lower levels of health, and this gap does not narrow later in life. Two potential explanations that we discuss in the next sections are the difference in pecuniary and non-pecuniary health investments across high school and college graduates.

2.3 Pecuniary Investment

Despite the gradients in health and survival, there is no gradient in aggregate healthcare spending. Figure 2 shows the evolution of healthcare spending over the life cycle for the two education groups. Two patterns emerge: (i) healthcare spending rises steeply over the life cycle, and (ii) there are no consistent differences over education in the slope or the level of medical spending over the life cycle.

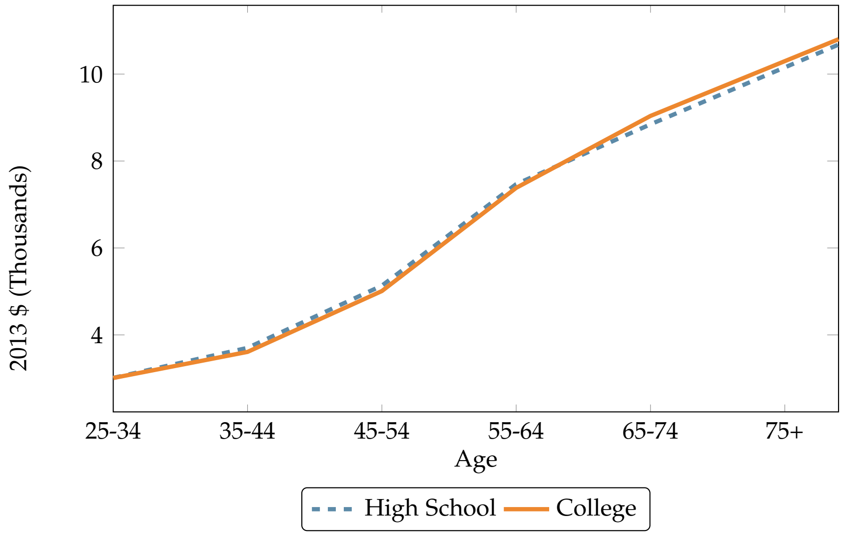

Figure 2: Total healthcare Spending by Education and Age

Notes: Total healthcare spending includes aggregate healthcare spending taking into account out-of-pocket medical spending, payments by private and public insurance and other sources, excluding over the counter drugs and indirect payments not related to specific medical events.

Source: MEPS, 2000-13.

However, decomposing medical spending between healthy and unhealthy individuals across educational attainment reveals that: (i) healthcare spending is substantially higher for unhealthy individuals than for healthy ones, and (ii) college graduates spend consistently more on healthcare for any level of health compared to high school graduates (Figure 3). College graduates invest more in their health both when healthy and unhealthy, but are less likely to become sick and incur high curative medical spending compared to high school graduates. Hence, the reason that healthcare spending on aggregate does not differ significantly across education levels is the distribution of healthy and unhealthy individuals across these socioeconomic groups (Figure 1b).

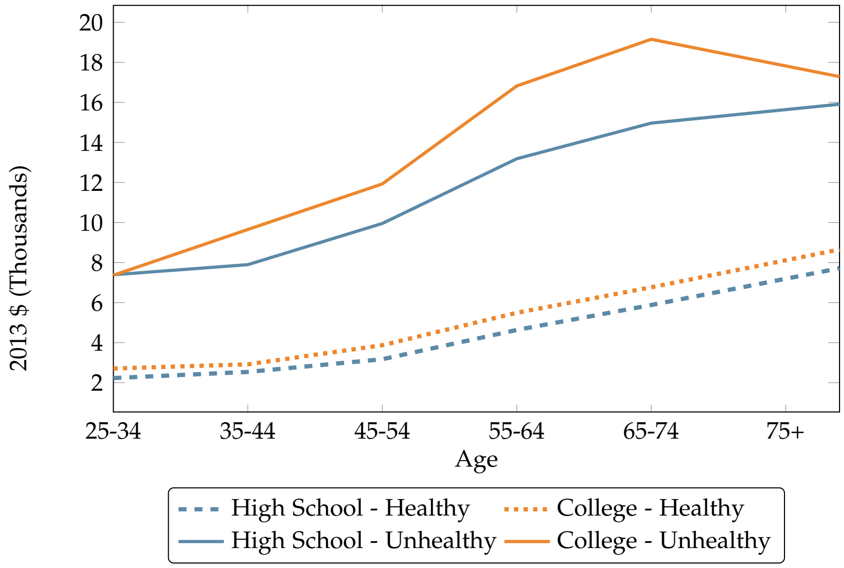

FIGURE 3: TOTAL HEALTHCARE SPENDING BY EDUCATION, HEALTH AND AGE

Notes: "Good Health" is defined as the self-reported level of health of "Good", "Very Good" or "Excellent" and "Bad Health" as a level of health of "Fair" or "Poor".
Source: MEPS, 2000-13.

In this paper, we distinguish between preventive medical spending that improves the level of health and curative medical spending that is increasing with poor health in order to rationalize the healthcare spending patterns across the education levels. We treat the former as a form of pecuniary investment that the agents choose in order to improve their health and the later as an expenditure shock that depends negatively on health. Due to the lack of a strict definition of preventive vs. curative medical spending in the data, we proxy preventive medical spending by the average healthcare spending of individuals in excellent health by education and age. We find that, on average, individuals that report "Excellent" health spend a quarter of what individuals with "Very Good" health or worse spend on medical care.

2.4 Non-Pecuniary Investment

The empirical literature has focused extensively on the positive relationship between socioeconomic status and health (Marmot et al., 1991), and on healthy behaviors in particular (Cutler and Lleras-Muney, 2010) which are important determinants of health. Nearly half of deaths in the United States are attributed to modifiable behavioral factors such as lack of exercise, smoking, excessive drinking and obesity Mokdad et al. (2004). In our model, we focus on a subset of positive health behaviors, which require time investment, such as, sports and exercise, self-care, and time spent in preventive medical services[5].

We document a strong correlation between education and time spent in health promoting activities. Figure 4 show the average hours per year spent on health promoting activities by education and age. There is a consistent gradient in non-pecuniary investment throughout the life cycle. Further, college graduates are ten percentage points more likely to participate in sports related activities and 3 percentage points more likely to engage in self-care activities compared to high school graduates[6].

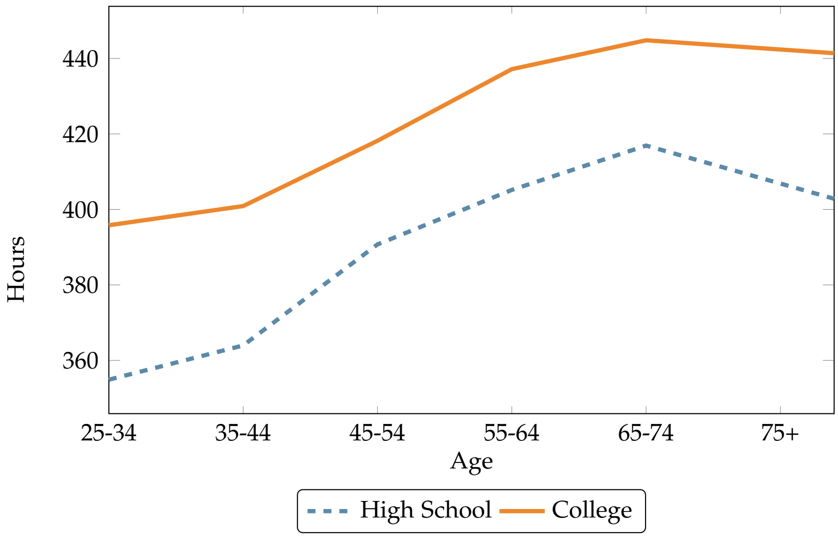

FIGURE 4: NON-PECUNIARY INVESTMENT BY EDUCATION AND AGE.

Notes: Non-pecuniary investment consists of total time spent on (i) sports and exercise, (ii) visiting doctor and (iii) selfcare (excluding sleep).
Source: ATUS, 2003-13.

In addition, college graduates are more likely to make use of preventive medical services, such as routine checks, flu shots and visiting the dentist. Table 1 shows the share of individuals across education categories who made use of common preventive medical services over the last 2 years.

Non-pecuniary investment is an important determinant of health, and given the gradient in

[5]Even though we do not explicitly consider negative health behaviors, our model indirectly accounts for the socioeconomic gradient in negative habits via two channels. First, agents enter the economy with a level of health that is conditional on their level of education. This encapsulates the adverse effects of negative behaviors on health until age 25. Second, we include a productivity penalty for the health investments of low educated individuals. While this is intended to capture the causal effect of education on health, it can also be thought to proxy for different health behaviors over education. For example, smoking reduces the effectiveness of money and time invested in health, while maintaining a healthy diet increases it.

[6]Despite the seemingly small differences in non-pecuniary investment, even a few minutes of moderate or vigorous exercise can have substantial effects on health outcomes, especially on medical conditions such as cardiovascular disease and type II diabetes, which are leading causes of mortality and morbidity (Gebel et al., 2015).

TABLE 1: Preventive Service Utilization over Education (in Last 2 Years)

Activity	Routine Check	Blood Pressure	Flu Shot	Dentist
High School	69.77%	82.06%	38.22%	49.75%
College	79.10%	90.07%	51.73%	71.56%

Notes: Percentage of individuals that report utilizing preventive medical services such as routine check, blood pressure check, flu shot and visiting the dentist within the last two years.
Source: MEPS, 2000-2013.

time spent in health promoting activities between high school and college graduates, plays a key role in our model.

2.5 Health Insurance

Pecuniary and non-pecuniary investments in health are intertwined with access to health insurance, meaning that individuals who are insured find these services more affordable and are more likely to utilize them. College graduates have, on average, better employment opportunities that offer higher labor income and better insurance options compared to high school graduates. Low educated individuals are less likely to receive a GHI offer from their employer. GHI offers better coverage, lower insurance premiums and are non-discriminatory with respect to pre-existing conditions relative to PHI. Figure 5 illustrates the gradient in health insurance access. At ages 25-34, approximately a third of high school graduates are uninsured and only half hold any type of private health insurance. They are also more likely to be covered only by public, means-tested health insurance provisions, a pattern which persists across all age groups with varying intensity. The percentage of uninsured individuals falls over the life cycle, especially for low educated individuals. However, the gap between high school graduates and college graduates is not eliminated until age 65, when all individuals are covered by Medicare.

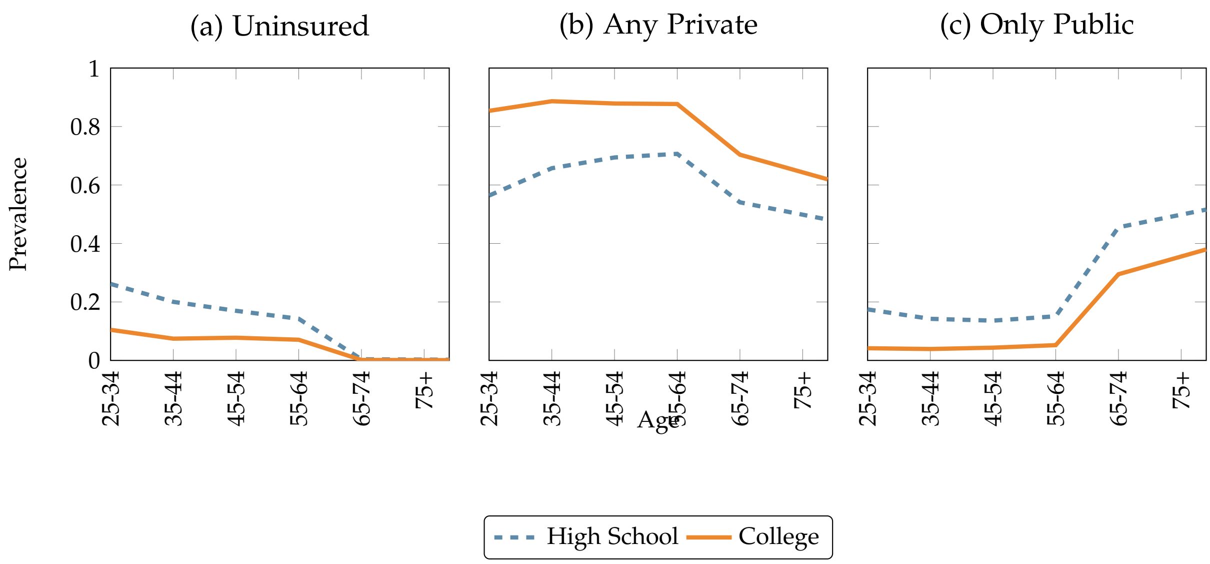

FIGURE 5: PREVALENCE OF INSURANCE COVERAGE BY EDUCATION AND AGE

Notes: Figure (a) shows the percentage of uninsured individuals over education. Figure (b) shows the percentage that has any type of private insurance and Figure (c) shows the percentage that is only covered by public insurance programs.
Source: MEPS, 2008-13.

However, access to healthcare cannot fully explain the gradients in pecuniary and non-pecuniary investments in health, nor the health and life expectancy gradients. First, Newhouse (1993) and Cutler and Lleras-Muney (2010) find that even controlling for health insurance status these services are underutilized by low educated individuals. Second, healthy behaviors are important determinants of health outcomes and life expectancy, and are not always correlated with access to health insurance. Third, to the extent that these services are utilized, the effectiveness across levels of education varies[7].

3 Model

In order to rationalize the choices of individuals and the life expectancy gap between different levels of education, we develop a life cycle model where heterogeneous agents make health-related decisions in a realistic institutional environment with both private and public health insurance. Agents are ex-ante heterogeneous over education and face uncertainty with respect to health, survival, curative medical spending, labor productivity and health insurance status. In the model, agents make decisions with respect to consumption and savings, pecuniary

[7]The gradient in the effectiveness of health investments can affect both health for any given level of health investments and the choice of said investments.

and non-pecuniary investments in health, health insurance, and labor supply (at the extensive margin).

3.1 Preferences and Demographics

Consider an economy populated by overlapping generations of agents. Each period a continuum of agents, who live for at most J periods, is born. At age $j = 0$, each agent "inherits" a level of education, which determines the life cycle profile of productivity, the initial level of health, the probability of being offered employer based health insurance, and the level of social security benefits starting from the age of eligibility J_R. The probability of survival is endogenous and depends on the level of health.

At the beginning of every period, agents observe the idiosyncratic productivity and health shocks, z_j^l and z_j^h respectively, and whether or not they are offered Group Health Insurance (GHI) $GHI_j \in \{0, 1\}$, and then make their health insurance decision. We make two simplifying assumptions: (i) individuals who received an offer the previous period, receive an offer in the current period as well, and (ii) individuals who are offered GHI are automatically enrolled in it[8]. Agents who are not offered GHI have the option of purchasing Private Health Insurance (PHI), provided their level of health is above a threshold[9]. After age J_R, individuals are automatically enrolled in Medicare. Subsequently, the medical spending shock is revealed and agents choose consumption, preventive medical spending, labor supply, time spent in health promoting activities and saving in the risk-free asset. Agents have the option to drop out of the labor market before age 63 and collect disability Insurance Benefits (DIB), if their level of health is below the qualifying threshold. The timeline of the decision process is outlined below:

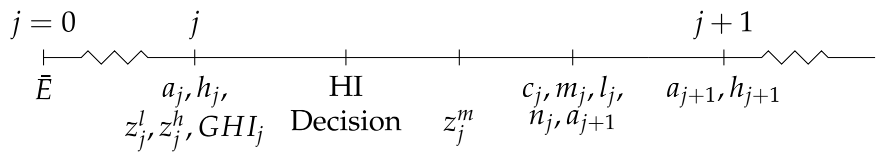

FIGURE 6: TIMELINE

Agents face the following lifetime utility:

[8] These assumptions reflect the high take-up ratios of GHI and the persistence of GHI contracts.

[9] We take into account the discrimination in the private health insurance market based on the level of health. Prior to the implementation of the Affordable Care Act, insurance firms could charge a premium based on pre-existing conditions for PHI but not GHI.

$$U=\sum_{j=1}^{J}\beta^{j-1}\left[\prod_{k=2}^{j}P_{k-1}\left(h_k\right)\right]\left[u_j\left(c_{i,j},l_j,n_j,h_j\right)+\left(1-P_j\left(h_{j+1}\right)\right)\theta\left(\alpha_{j+1}\right)\right] \tag{1}$$

where β is the subjective discount factor, $P_{k-1}(h_k)$ the endogenous conditional probability of survival from age $k-1$ to k and $\theta(\alpha_{j+1})$ the utility derived from accidental bequest if the agent doesn't survive to the next period. The instantaneous utility $u_j(c_{i,j},l_j,n_j,h_j)$ is

$$u_j\left(c_j,l_j,n_j,h_j\right)=\pi_h+\frac{c_j^{1+\sigma}}{1+\sigma}+v_0\frac{h_j^{1+\gamma}}{1+\gamma}-v_1\frac{\left(l_j^{1+\frac{1}{\eta}}+\chi_j\right)^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}}-v_2\frac{n_j^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \tag{2}$$

where c_j, h_j, l_j and n_j denote consumption, health, labor supply and time spent in healthy activities respectively, and π_h is a constant parameter in the utility function[10]. The parameter χ_j is the age-specific utility cost of labor supply (in periods with positive hours of work), which helps to capture the take up of disability benefits over the life cycle.

We choose this utility function because of its salient properties, allowing us to take into account the effects of health on the quality and quantity of life. Agents derive utility from health directly, and can enjoy more periods of flow utility because of higher probability of survival. Furthermore, this utility function helps shed light on the gradients of pecuniary and non-pecuniary investments. Agents face an intra- and intertemporal trade off between consumption and health. Namely, agents need to sacrifice current consumption in order to increase: (i) their current level of health, and (ii) their life expectancy. Since consumption faces diminishing returns, the willingness to pay for health improvements rises with wealth.

3.2 Health

As in Grossman (1972), we model health as a stock. Agents can invest pecuniary and non-pecuniary resources in order to increase their level of health, which depreciates stochastically over the life cycle. The law of motion for an agent of education i is denoted by[11]:

$$h_{i,j}=\left(1-z_j^h\right)h_{i,j-1}+Q_{i,j}\left(\lambda m_{i,j}^{\psi}+(1-\lambda)\left(n_{i,j}\right)^{\xi}\right) \tag{3}$$

[10] In standard models with exogenous probability of survival, only the marginal utility matters. However, when the probability of survival is endogenous, agents make decisions with respect to medical spending that affect the lifetime utility on the extensive margin. Hence, the constant parameter π_h affects the incentives of the agents to invest in their level of health.

[11] For clarity, we suppress the notation for the education types when the parameters are not education specific.

where z_j^h is the stochastic depreciation of health, and $m_{i,j}$ and $n_{i,j}$ are the pecuniary and non-pecuniary investments in health, respectively. ψ and ξ determine the degree of diminishing returns of pecuniary and non-pecuniary investment in health respectively, and λ determines their relative weights in the health production function[12].

$Q_{i,j}$ determines the productivity of pecuniary and non-pecuniary investments, and it is assumed to be age and education specific in order to take into account the strong correlation between the effectiveness of medical services utilization and education[13].

3.3 Medical Spending and Health Insurance

Agents face uncertainty with respect to total out-of-pocket medical spending μ_j. Out-of-pocket medical spending consists of the insurance premium, if the agent holds health insurance, and two distinct types of medical spending, preventive medical spending, m_j, that agents choose in order to increase their health, and stochastic curative medical spending, z_j^m, that needs to be paid in order to survive to the next period. The distribution of the curative medical spending shocks depends on age, health and education.

The total out-of-pocket medical spending for the insured is denoted by:

$$\mu_j = m_j + z_j^m + pr_j\left(ins_j\right) - q\left(ins_j\right)\left(m_j, z_j^m\right) \tag{4}$$

Conversely, for the uninsured it is:

$$\mu_j = m_j + z_j^m \tag{5}$$

where pr_j denotes the insurance premium, q the coinsurance rate and ins_j the insurance status. The coinsurance rate is the fraction of total medical spending that is covered by health insurance[14].

There are five health insurance states in our model: Medicaid, Medicare, Group Health Insurance (GHI), Private Health Insurance (PHI), and no insurance. Until age 65, agents that did

[12]The parameters that control the concavity of health investments ensure that wealthy individuals cannot achieve an unrealistically high probability of survival, since they face diminishing returns.

[13]For a discussion on the education gradient in the effectiveness of complex medical technology see Cutler and Lleras-Muney (2006).

[14]In this model, we consider the effective coinsurance rate, which takes into account both the fraction of out-of-pocket medical spending for healthcare services that are covered and medical spending that the individual pays fully out-of-pocket because they are not covered under the health insurance plan. For example, not all health insurance schemes offer coverage for dental care, which would tend to decrease the effective coinsurance rate.

not receive a GHI offer in previous periods face uncertainty with respect to their insurance status. Agents that do not hold GHI face an education and age-specific probability $\zeta\left(\bar{E}, j\right)$ of receicing GHI. A GHI offer translates into automatic enrollment in the GHI scheme for the current and all subsequent periods, with a uniform coinsurance rate and health insurance premium. This simplification reflects the high enrollment rate of workers that receive a GHI offers as well as the persistence of GHI.

If the agent does not receive GHI, he/she can choose to purchase PHI, which offers a lower coinsurance rate and a premium that depends on the health status of the applicant. Agents can be denied PHI, if health is below a certain threshold. The health insurance premium is denoted by:

$$pr\left(PHI\right) = \left(1+\omega\right) E\left(z_j^m | h_j, j, \bar{E}\right) \tag{6}$$

where ω is the markup that the insurance firms charges and $E\left(z_j^m | h_j, j, \bar{E}\right)$ is the expected curative medical spending of the agent, given the agent's health, age and education level.

The government offers two health insurance schemes: (i) means-tested Medicaid that is offered to individuals with income below the Medicaid threshold or who need to pay a curative medical spending shock that does not allow them to achieve a minimum level of consumption guaranteed by the government, and (ii) Medicare for all agents over the age of 65. In a nutshell:

$$ins_j = \begin{cases} Medicare, & if \quad j \geq J_R \\ Medicaid, & if \quad c < \bar{c}, \quad y < y_{Medicaid} \\ GHI, & if \quad ins_{j-1} = GHI, or \quad w/prob. \quad \zeta\left(\bar{E}, j\right) \\ PHI & \\ Uninsured & \end{cases} \tag{7}$$

where $\bar{c}$ is the minimum level of consumption guaranteed by the government and $y_{Medicaid}$ is the income threshold for Medicaid eligibility.

The coinsurance rate is uniform across agents that hold PHI, but the insurance premium varies. Agents that hold GHI face a fixed premium, while the insurance premium for PHI is equal to the conditional expectation of medical spending for each individual plus a markup. Prior to the implementation of the ACA, only GHI was required by law not to discriminate based on health status, while PHI faced no such restrictions[15]. Consequently, older or un-

[15]For a detailed discussion regarding the institutional differences between GHI and PHI see inter alia Jeske and Kitao (2009). In this paper, we do not consider the deductible on the GHI premium nor the pooling effects on the level of the health insurance premium.

healthy individuals who are not denied PHI due to their health face on average a higher premium.

Thus, agents face uncertainty with respect to both the magnitude of the curative medical spending shock and their health insurance status before the age of 65, and only the magnitude of the curative medical spending shock after the age of 65. Moreover, agents that do not receive GHI and do not qualify for Medicaid, face the risk of a health shock that can: (i) reduce their level of health below the threshold that makes them eligible for PHI, or (ii) increase the health insurance premium that the agent needs to pay in order to purchase PHI.

3.4 Budget Constraints

The agent receives labor income if working, capital income, government transfers if necessary to guarantee a minimum level of consumption, disability insurance benefits if the level of health is below the DIB threshold, and social security benefits after the eligibility age. The agent allocates resources between general consumption, out-of-pocket medical spending and savings:

$$\tilde{y}_j = (1 + \tau^c)\, c_j + \mu_j + a_j \tag{8}$$

$\tilde{y}_j$ denotes total net income:

$$\tilde{y}_j = \left(1 - \tau\left(y_j\right)\right) y_j \tag{9}$$

The total income of the agent depends on labor supply, labor productivity, capital income and government tranfers if applicable:

$$y_j = l_j e\left(h_j, j, z_j^n, \bar{E}\right) + (1 + r)\, a_{j-1} + Tr_j + ss_j + DIB_j \tag{10}$$

where $e\left(h_j, j, z_j^n, \bar{E}\right)$ denotes the labor productivity as a function of health, age, education and the labor productivity shock, a_{j-1} the level of assets, Tr_j government transfers , ss_j social security payments, and DIB_j disability insurance benefits.

3.5 Government

The government collects taxes via a progressive earnings tax and a flat tax on consumption. We use the income tax function as described in Guner, Kaygusuz and Ventura (2014), which provides a good approximation of the progressivity of the average income tax in the U.S.:

$$\tau\left(y_j\right) = 1 - \tau_0 y_j^{\varphi} \tag{11}$$

In this specification, τ_0 controls the level of the average income tax and φ the degree of progressivity, with $\varphi = 0$ implying a constant tax over income.

In addition, the government provides means-tested social insurance programs, and social security benefits and Medicare after the eligibility age. In particular, the government provides Medicaid for agents with income below the Medicaid threshold or facing curative medical spending shocks that do not allow the agent to achieve a minimum level of consumption. In addition, the government provides Disability Insurance Benefits to agents who drop out of the labor market and whose level of health is below the DIB threshold.

3.6 Individual's Problem

Let $V_j\left(a_j, h_j, z_j^l, z_j^h, z_j^m, GHI_j, i\right)$ denote the value of an age-j agent with assets a_j, level of health h_j, idiosyncratic productivity, health and medical shocks z_j^l, z_j^h and z_j^m respectively, group health insurance option GHI_j and level of education i and $s_j = \left(a_j, h_j, z_j^n, z_j^h, z_j^m, GHI_j, i\right)$ the state vector. We can write the agent's problem recursively as:

$$V_j\left(s_j\right) = \max_{c_j, l_j, l_j^h m_j, ins_j} \left\{ \begin{array}{l} u_j\left(c_j, l_j, h_j\right) + \beta\left(1 - P\left(h_j\right)\right)\theta\left(a_{j+1}\right) \\ +\beta P\left(h_j\right) \int V_{j+1}\left(s_{j+1}\right) dF\left(s_{j+1}\right) \end{array} \right\} \tag{12}$$

subject to the budget constraint (8), out-of-pocket medical spending (4) - (6) and the health production function (3).

4 Parameterization

We follow a two-step procedure for the parameterization of the model. First, we estimate as many parameters as possible directly from the data, and set some parameters based on commonly adopted values in the literature. Second, we use Indirect Inference for the vector of remaining parameters, in order to minimize the weighted distance between moments generated from the model simulations and their data counterparts.

4.1 Estimated Parameters

The parameters estimated from the data are: (i) the age-specific baseline mortality risk, (ii) the sensitivity of the mortality risk to health, (iii) the distributions of educational attainment and initial health in the population, (iv) the distribution of health shocks, (v) the distribution of curative medical spending shock, (vi) the probability of receiving a GHI offer, and (vii) the labor income process.

4.1.1 Demographics

Mortality risk is endogenous, and depends on age and health:

$$p_j^d\left(h_j, j\right) = \bar{p}_j^d \exp\left(\rho_h\left(h_j - h_{\max}\right)\right) \tag{13}$$

Agents across different levels of education face the same, age-specific mortality risk, $\bar{p}_j^d$, which corresponds to the mortality hazard of an individual in excellent health, and any deviations from the optimal level of health amplify the mortality risk.

The sensitivity of the mortality risk to health, ρ_h, is estimated such that, given the average level of health over the life cycle for high school graduates and college graduates in the MEPS, the life expectancy gap is 5.5 years. The baseline mortality risk, $\bar{p}_j^d$, is estimated using data on the number of deaths by age from the CDC and population estimates by age from the ACS.

The distribution of agents over education is computed using data on educational attainment in MEPS. Each agent is also endowed with an initial level of health, which is conditional on education. Again, this is constructed using MEPS data. High school graduates enter the economy with lower health on average, compared to college graduates.

Table 2: Distribution of Education and Health at Age 25

Education	Share	Bottom Health Quartile	Average Health	Top Health Quartile
High School	61.0%	3.33	3.83	4.33
College	39.0%	3.67	4.12	4.67

Notes: Descriptive statistics for the distribution of education and health at age 25. Self reported levels of health are "Poor", "Fair", "Good", "Very Good" and "Excellent" which are converted to numerical values 1 to 5. *Source*: MEPS, 2000-13.

In the model, differences in initial health reflect differences in childhood/early adulthood health, which we do not model, but that can have substantial effects on health and longevity over the life cycle. In the Decompositions Section, we shut down the heterogeneity in initial health, and estimate its relative importance in accounting for the health gradient.

4.1.2 Gradient in Effectiveness of Health Investments

The gradient in the effectiveness of health investments plays a key role in our model in accounting for both the health gradient per se, as well as individuals' choices regarding pecuniary and non-pecuniary investments in health. Gilleskie and Harrison (1998) estimate the effects of an extra year of education on the productive and allocative efficiency of health investments. Productive efficiency refers to the effectiveness of pecuniary and non-pecuniary investments, while allocative efficiency refers to the efficiency of the allocation between different types of health investments (e.g., the allocation between preventive medical care and exercise). In our model, we consider only the former. Agents are rational and always choose the optimal allocation of health investments given their constraints, but the effectiveness of each dollar and minute spent in health is education specific. The different allocation of health investment inputs is the result of different constraints that the individuals face.

Each year of education improves productive efficiency by 1.68%, and, given the difference in the average years of schooling between low and high educated individuals, we estimate that the investments of high school graduates are 7.2% less effective than those of college graduates.

4.1.3 Health Shocks

Recall that, in our model, agents make pecuniary and non-pecuniary investments which build up the health stock, but face negative shocks which in turn deplete this stock. We estimate the distribution of health shocks using individual level data on medical conditions from the MEPS and the corresponding severity index for each medical condition from the WHO's Global Burden of Disease, similarly to Prados (2017)[16]. A health shock is defined as the cumulative severity index for all conditions reported by an individual in a particular wave of the MEPS.

Figure 7 shows the 5th, 25th, 50th, 75th and 95th percentiles of health shocks by age and education. Health shocks become more severe and dispersed with age. Furthermore, the severity of extreme health shocks is larger for high school graduates than for college graduates.

[16]The severity index for each condition is between zero (conditions that do not have any effect on the quality or quantity of life) and one (conditions that result in death).

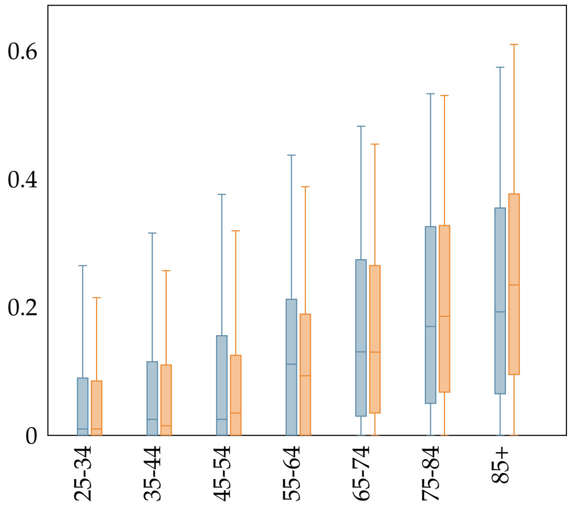

FIGURE 7: DISTRIBUTION OF HEALTH SHOCKS BY AGE AND EDUCATION

Notes: The graph presents the distribution of health shocks by age and education, as measured by the cumulative health condition severity weights. The line represents the mean, the edges of the box the 25th and 75th percentiles and the whiskers the 5th and 95th percentiles. The blue and orange boxplots represent the health shock distributions of high school and college graduates, respectively.

Source: MEPS Conditions File (2000-13) and WHO's Global Burden of Disease (2002).

In the context of our model, health shocks are approximated by a discrete, 3-state process, which depends on age and health, similar to De Nardi, Pashchenko and Porapakkarm (2018). First, we construct three health shock groups, below 50th percentile, between 50th and 95th percentile and above 95th percentile. Individuals are grouped into these bins, conditional on age, education and health. We then run a regression of the level of health shocks on age, age squared, health, health squared and education, separately for each bin.

In the model, agents draw a health shock bin with the corresponding probability, and the severity of the shock is determined by age and health.

FIGURE 8: DISTRIBUTION OF HEALTH SHOCKS FOR HIGH SCHOOL GRADUATE

Notes: We use our parameter estimates to generate the distribution of health shocks over the life cycle for a high school graduate with level of health of (a) "Very Good" and (b) "Poor".

Figure 8 shows an example of the distribution of shocks that an individual faces over the life cycle for different levels of health. The model takes into account that health shocks on average increase with age, and that unhealthy individuals face more severe health shocks.

4.1.4 Curative Medical Spending

Agents face curative medical spending shocks that need to be paid in order to survive to the next period. We estimate the distribution of these shocks with the same methodology as the distribution of health shocks. We construct three bins for medical expenditures, below 50th, between 50th and 95th and above 95th percentile. Individuals are then grouped into these bins, conditional on age, education and health. We then regress medical expenditures on age, age squared, health, health squared and education.[17]

[17] Recall that we proxy preventive medical spending by the average healthcare spending of individuals in excellent health, which corresponds to a quarter of the average healthcare spending of individuals with very good health and below. Hence, we adjust our estimates of curative medical spending by multiplying by 0.75. This is necessary in order to not overestimate aggregate healthcare spending.

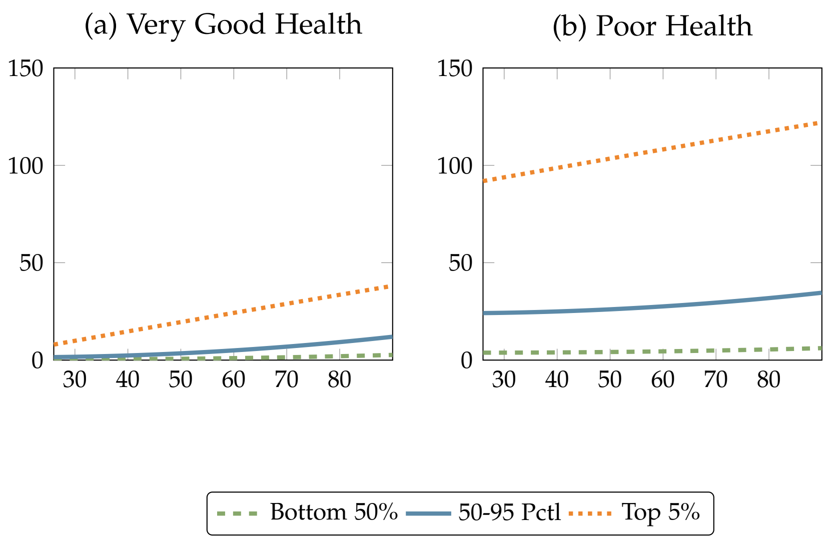

FIGURE 9: DISTRIBUTION OF CURATIVE MEDICAL SHOCKS FOR HIGH SCHOOL GRADUATE

Notes: We use our parameter estimates to generate the distribution of curative medical spending shocks over the life cycle for a high school graduate with health of (a) "Very Good" and (b) "Poor".

Figure 9 shows the distribution of curative medical spending shocks over the life cycle for a high school graduate with "Very Good" and "Poor" health, respectively. Unsurprisingly, unhealthy individuals face on average higher curative medical spending shocks, and face a positive probability of experiencing catastrophic curative medical spending shocks even at younger ages. In addition, our estimation strategy allows for low curative medical spending shocks even for older individuals with poor health, reflecting the prevalence of agents that do not have any medical spending in a given year.

4.1.5 Health Insurance

The probability of receiving GHI has an upward trend, which reflects better employment opportunities over the life cycle. We estimate the age and education specific probability of receiving an offer by estimating the increase in GHI over the life cycle[18].

We estimate the effective coinsurance rates for GHI, PHI, Medicaid and Medicare from MEPS data, using the share of total medical spending that is paid out-of-pocket. At 90%, Medicaid offers the most generous coinsurance rate. This is hardly surprising, considering that Medicaid is a means-tested program targeted at individuals with low income or those that face

[18] Recall that GHI is an absorbing state. This means that once agents receive a GHI offer, they keep their health insurance status until age 65, when they switch to Medicare. In order to generate life cycle profiles of uninsured individuals that are close to the data, the probability of receiving an offer is simply the increase of individuals that are covered by GHI from age j to $j+1$ in percentage points.

catastrophic healthcare spending which they are not able to pay out-of-pocket. Medicare and GHI offer similar coinsurance rates, while the coinsurance rate offered by PHI is lower.

Table 3: Health Insurance Coinsurance Rate and Premium

Type of Insurance	Copay Rate	Insurance Premium
GHI	0.71	1947
PHI	0.67	See text
Medicare	0.73	547
Medicaid	0.9	0

Notes: The copay rates are computed as the fraction of total medical spending paid out-of-pocket. The GHI premium is estimated using MEPS data and the PHI is set endogenously in the model.
Source: MEPS, 2000-13.

The health insurance premiums for GHI and Medicare are estimated using MEPS data. The health insurance premium for GHI is estimated using the average health insurance premium and the share covered by the employer. We find that on average, individuals pay $1947 out-of-pocket annually. The insurance premium for PHI is endogenous in our model, and depends on the expected medical spending of the individual plus a markup, which is calibrated such that the fraction of uninsured in the model is close to the data. We assume that Medicaid has an effective insurance premium equal to zero.

4.1.6 Labour Productivity

The stochastic labor productivity profile is endogenous, and depends on age, education, and health. PSID has data on self-reported health, which we use in order to estimate the effect of health on productivity. We estimate the following polynomial of age, health and education in order to approximate the labor productivity process[19]:

$$\log\left(e_{i,j}\right) = \varepsilon_o + \varepsilon_1 j + \varepsilon_2 j^2 + \varepsilon_3 h + \varepsilon_4 h^2 + \varepsilon_{\bar{E}} + z_j^l \tag{14}$$

$$z_j^l = \rho z_{j-1}^l + \varepsilon_j \tag{15}$$

$$\varepsilon_j \sim N\left(\mu_\varepsilon, \sigma_\varepsilon^2\right) \tag{16}$$

[19] The regresssion results are presented in Table A4 in the Appendix.

Productivity has the familiar age profile with an autoregressive component, and both education and health have a positive effect on productivity. We estimate the autoregressive component with a correlation coefficient $\rho = 0.945$ and a normally distributed innovation ε_j with mean $\mu_\varepsilon = 0$ and variance $\sigma_\varepsilon^2 = 0.3$.

4.2 Exogenous Parameters

Here we present the parameters that are set exogenously to values that are commonly found in the literature.

4.2.1 Preferences and Demographics

A model period is two years. Agents enter the economy at age of 25 ($j = 1$) and survive until at most age 89 ($j = 33$). Population growth is set to 3% annually[20].

TABLE 4: Demographics

Parameter	Description	Value
J	Maximum Number of Periods	35 (94 years old)
J_R	Retirement Period	20 (65 years old)
n	Population Growth	0.06 (3% annually)

We set the coefficient of relative risk aversion to $\sigma = 2$, a standard value in models where agents face medical spending shocks. The Frisch elasticity of labor supply, η, and the concavity of the disutility of non-pecuniary investment, γ, are set to $1/3$. The discount factor is set to $\beta = 0.97$.

TABLE 5: Preference Parameters

Parameter	Description	Value
β	Discount Factor	0.97
σ	Coefficient of Relative Risk Aversion	3
η	Frisch Elasticity	0.33
γ	Concavity of Disutility from Healthy Time	0.33

Notes: Parameters set according common values in the literature.

[20]Population growth is necessary to ensure that cohorts have the correct size, in particular for our counterfactual analysis.

4.2.2 Government

We set the consumption tax τ^c to 5%, a common value in the literature, and use the estimates of Guner, Kaygusuz and Ventura (2014) for the parameters of the income tax function.

Parameter	Description	Value
τ_0	Tax Level	0.902
ϕ	Tax Progressivity	0.036
τ^c	Consumption Tax	0.05

Source: Guner et al. (2014).

It is not feasible to track the lifetime earnings of agents in order to calculate social security benefits. Instead, we estimate average labor income by education and apply the below social security benefit formula to these averages, as in Zhao (2017).

Average Lifetime Earning	Marginal Replacement Rate
$y_i \in [0, 0.2\bar{y})$	90%
$y_i \in [0.2, 1.25\bar{y})$	33%
$y_i \in [1.25, 2.46\bar{y})$	15%
$y_i \in [2.46, \infty)$	0%

Source: Zhao (2017). $\bar{y}$ is the average labor income in the economy and y_i is the average labor income at each level of education i.

4.3 Indirect Inference

The rest of the parameters in the model are jointly estimated using Indirect Inference. The targeted moments consist of: (i) mean preventive healthcare spending by age and education (12 moments)[21], (ii) mean level of health by age and education (12 moments), (iii) share of uninsured (1 moment), (iv) mean time spent in healthy activities by education (2 moments), and (v) employment rate at age 63 (1 moment). We are, thus, targeting 28 moments in total.

The estimated parameters are: (i) the effectiveness of health investments ($Q_{i,j}$)[22], (ii) the weight on time spent in healthy activities in the health production function (λ), (iii) the concavity of

[21] Recall that we proxy preventive investment in health by the average medical spending of individuals in excellent health. Thus, the ratio of healthcare spending of individuals with excellent health over aggregate healthcare spending is used to estimate the fraction of aggregate health care spending that is preventive in nature. The distribution of medical spending shocks, which is estimated in the previous section, is based on the residual medical spending. Hence, preventive health investments and medical spending shocks sum to the aggregate health care spending that we observe in the data.

[22] The scale of the effectiveness of health investments is set such that, given the inputs of pecuniary and non-pecuniary investments, the level of health is the one we observe in the data. The gradient in the efficiency of health investment exogenously scales down Q_j for high school graduates.

preventive medical spending and time spent in healthy activities in the health production function (ψ and ξ respectively), (iv) the education-specific disutility from labor supply ($v_{i,1}$), (v) the education-specific disutility from time spent in healthy activities ($v_{i,2}$), and (vi) the weights on health in utility (π_h, k, v_0). In order to reduce the parameter space, we approximate $Q_{i,j}$ with a linearly spaced vector, and estimate the starting and ending points instead of the full vector.

We choose the parameter vectors to minimize the distance between the model generated variables and their data counterparts for each age bin. We use 10-year intervals (25-34,...,65-74,75+). Formally:

$$\hat{\boldsymbol{\theta}} = \arg\min \left[\hat{\psi}^d(\boldsymbol{\theta}) - \hat{\psi}^s(\boldsymbol{\theta})\right]' W \left[\hat{\psi}^d(\boldsymbol{\theta}) - \hat{\psi}^s(\boldsymbol{\theta})\right] \tag{17}$$

where $\hat{\boldsymbol{\theta}}$ is the vector of parameters to be estimated, $\hat{\psi}^d$ and $\hat{\psi}^s$ are the vectors of data and simulation moments respectively, and W is the weighting matrix. We use the inverse of the bootstrapped standard errors as weights. This accomplishes two tasks: scales the distance between vectors of moments that are measured in different units, and gives relatively higher weight to moments with lower variance.

5 Model Fit

The model does quite well in matching the targeted moments. In particular, the model generates the differences in health over education observed in the data; see Figure 10. High school graduates enter the economy with a lower level of health than their more educated counterparts, and the gap does not narrow later in life. This is driven by three factors: (i) high school graduates invest less pecuniary and non-pecuniary resources in their health, (ii) the effectiveness of said investments is lower for less educated individuals, and (iii) a lower level of health implies more severe health shocks in our model. The model predicted gap in life expectancy between high school and college graduates is 6.4 years, slightly larger than the 5.5 years estimated from the data.

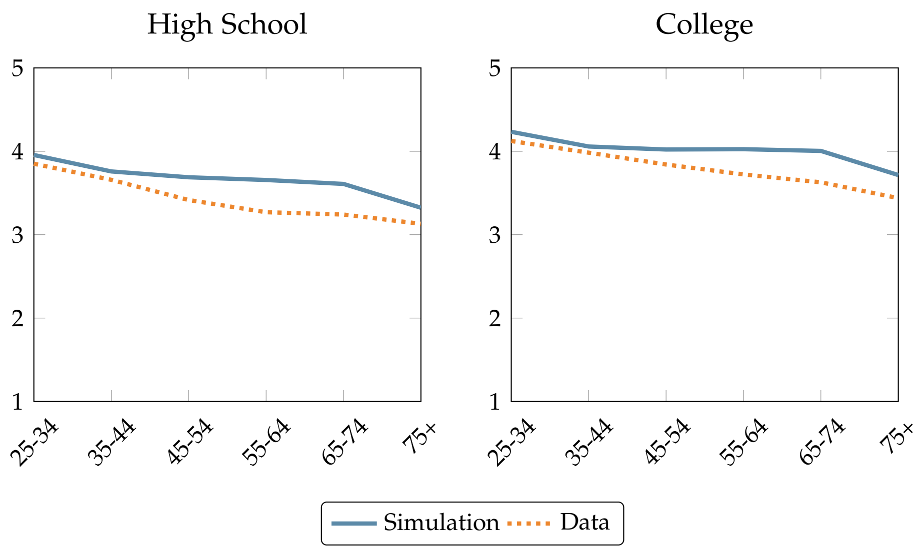

Figure 10: Health by Education and Age

Notes: Health by education and age, model vs. data. In the data, 5 corresponds to "Excellent Health" and 1 to "Poor Health". In the model, health is a continuous variable (normalized).
Source: MEPS (2000-13) and simulation results.

Preventive medical spending increases over the life cycle for both high school and college graduates, although college graduates invest consistently more in their health than high school graduates (see Figure 11). The rise in spending over the life cycle is consistent with the increase in the magnitude of shocks with age. Recall that we assume that the effectiveness of health investments increases with age. This captures the fact that many preventive procedures are only reasonable after a certain age. The model predicted slight fall in pecuniary investment at older ages, which is contrary to what we see in the data, is due to the fact that, in finite horizon models with endogenous probability of survival, agents face a terminal period where they die with certainty. This reduces their incentives to invest in health during the last periods of life.

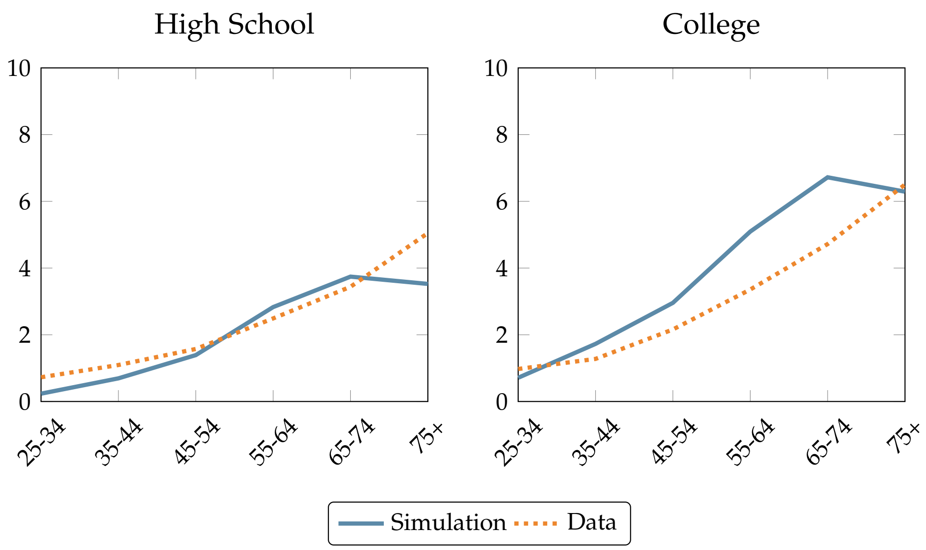

Figure 11: Preventive Healthcare Spending by Education and Age

Notes: Preventive medical spending by age and education, model vs. data. In the data, we proxy preventive medical spending by the average healthcare spending of individuals in excellent health.

Source: MEPS (2000-13) and simulation results.

Despite college graduates enjoying better health on average than their less educated counterparts, they face larger curative medical spending shocks in our model (see Figure 17). While one could argue that the higher curative spending of college graduates relative to high school graduates is a choice, this is a parsimonious way of capturing the fact that the differences in curative spending largely reflect amenities (e.g., private vs. shared hospital room). Moreover, in our model, college graduates spend on average 10% more time in health related activities than high school graduates, compared to 7% in the data.

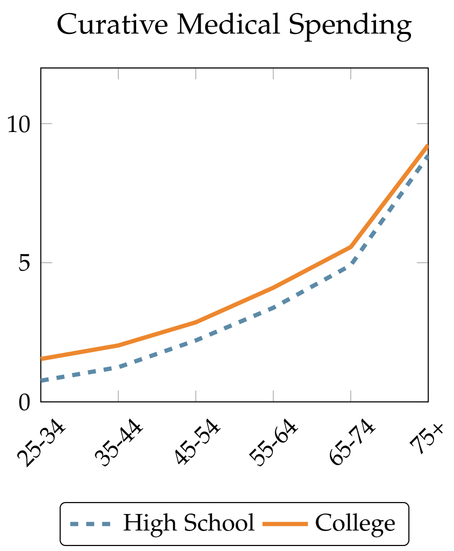

FIGURE 12: CURATIVE MEDICAL SPENDING

Notes: Preventive and curative medical spending by age and education. Curative medical spending refers to the medical spending that agents must pay in order to survive to the next period.
Source: Simulation results.

Lastly, the model also generates education differences in the prevalence of health insurance coverage. As seen from Table 6, 25.44% of high school graduates and 12.18% of college graduates below age 65 are uninsured in the model, compared with 21.09% and 11.51% in the data.

TABLE 6: Model Fit

Variable	Simulation	Data
Uninsured (High School)	25.44%	21.09%
Uninsured (College)	12.18%	11.54%
Ratio of non-Pecuniary Investment (College/High School)	1.11	1.07
Life Expectancy Gap	6.4	5.5
DIB at age 54-65 (High School)	17.27	17.21
DIB at age 54-65 (College)	10.36	10.88

Notes: The table shows data and simulations moments for: (i) percentage of uninsured for high school graduates and (ii) college graduates, (iii) the ratio of non-pecuniary investment of college graduates over high school graduates, and the prevalence of DIB by education.
Sources: MEPS (2000-13), ATUS (2003-13), PSID (2000-13), CDC (2000-13), ACS(2000-13) and simulation results.

5.1 Value of Life

In models with endogenous life expectancy, the so called Value of Statistical Life (VSL) is an important moment. This is not something we target. As such, it is informative about the external validity of our results. In particular, given that the model fits the level of pecuniary investment quite well, the VSL ensures that the parameterization of the health production function is reasonable. We estimate the VSL as the inverse of the marginal effect of preventive medical spending on the survival probability[23]. For example, if reducing the mortality at age 50 by 1 percentage point costs $10,000, then saving a statistical life requires 100 people to make this investment, for a total cost of 1 million USD. Conversely, the monetary value of living an extra year is the VLS divided by life expectancy. Thus, the value of living an extra year for a 50-year old with a life expectancy of 30 years would be $33,333.

Table 7 shows the VLS by age and education. Our estimates lie within the range of estimates from the literature (see, e.g., Hall and Jones (2007) and Murphy and Topel (2006)). The VSL of college graduates is substantially higher compared to high school graduates. This is driven by the higher pecuniary investments of college graduates, which result in the diminishing returns to health investment being more pronounced for this group. Note that the gradient in the effectiveness of health investments has an opposing effect, as the investments of high school graduates are less effective than those of college graduates.

TABLE 7: Value of Statistical Life in Thousands

Age	Average	High School	College
25	8908	2330	17690
35	5496	2844	8958
45	5382	2823	8634
55	4355	2416	6719
65	4231	2511	6212
75	2584	1436	3813

Notes: Estimates for the value of statistical life by age and education using the inverse of the marginal effect of medical spending on the probability of survival.

The value of an extra year of life (Table 8) paints a similar picture. College graduates are willing to spend substantially more on preventive medical spending than high school graduates in order to survive an extra year.

[23]Since the probability of survival is a function of health we make use of the chain rule: $VLS = \frac{1}{\frac{\partial p}{\partial h}\frac{\partial h}{\partial m}}$.

Table 8: Value of Extra Year of Life in Thousands

Age	Average	High School	College
25	81.34	22.63	149.11
35	54.47	30.03	81.97
45	59.82	33.38	88.71
55	56.78	33.43	81.24
65	69.23	43.43	94.82
75	58.27	33.85	80.93

Notes: Estimates for the value of extending life by one year by age and education. We divide the VLS with the life expectancy of each demographic.

In sum, our model reproduces the gradients in health investments and life expectancy. However, since agents are heterogenous along several dimensions, it is not clear what the main drives of these patterns are. In order to disentangle the importance of income inequality, differences in the initial level of health, and the gradient in the effectiveness of health investments on the differences in health and life expectancy over education, we perform decomposition exercises in the next section.

6 Decompositions

We focus on the main sources of heterogeneity between the two education types in our model, namely differences in the effectiveness of health investments, income, and initial levels of health. We shutdown each channel in turn, and assess its impact on pecuniary and non-pecuniary health investments, health, and life expectancy. We keep all other parameters fixed at the benchmark values.

6.1 Gradient in Effectiveness of Health Investments

The quantitatively most important driver of health inequality in our model is the gradient in the effectiveness of health investments. Eliminating differences along this margin reduces the life expectancy gap by 3.3 years. In this exercise, we assume that high school graduates face the same effectiveness of health investment as college graduates. Despite the relatively small difference in the effectiveness of health investments across education types in the benchmark model, eliminating this difference has a substantial effect on the life expectancy gap between high school and college graduates. There are three underlying forces at play: (i) for any given level of investment, the health investments of high school graduates now result in improved health and longer life expectancy, (ii) improving the effectiveness of high school graduates' health investments changes the incentives to make pecuniary and non-pecuniary health investments, and (iii) healthier agents face on average less severe health shocks. Effects (i) and (iii) contribute to the narrowing of the life expectancy gap, while effect (ii) actually works in the opposite direction, as high school graduates reduce pecuniary and non-pecuniary investments when they become more effective. The effects of this exercise on health investments and the level of health of high school graduates are summarized in Figure 13.

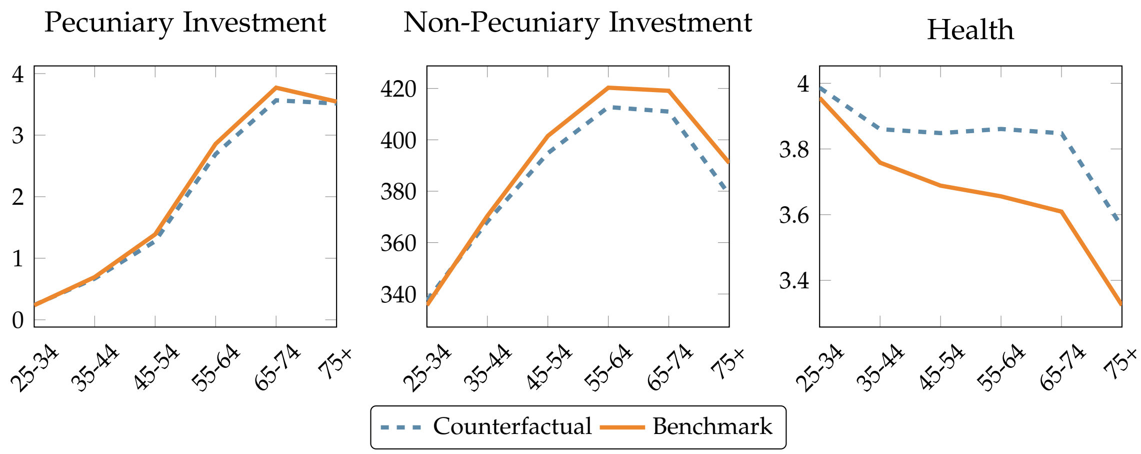

FIGURE 13: ELIMINATING DIFFERENCES IN EFFECTIVENESS OF HEALTH INVESTMENTS

Notes: Pecuniary and non-pecuniary health investments and level of health of high school graduates when shutting down the gradient in the effectiveness of health investments.
Source: Simulation results.

Recall that we do not estimate the difference in the effectiveness of health investments over education, rather we take it from Gilleskie and Harrison (1998). Estimating the causal effect of education on health and mortality is no easy feat. Some of the most compelling evidence comes from studies using changes in mandatory schooling laws. These studies find large positive effects of schooling on life expectancy. To compare our predicted effects with these empirical estimates, we simulate a schooling reform that increases the years of schooling of low educated individuals by one year. In the counterfactual, the gap in years of schooling falls, decreasing the gap in the productivity of health investments. We find that a one year increase in schooling results in a one year increase in life expectancy. While sizable, this is a more modest effect than the 1.7 year increase estimated by Lleras-Muney (2005) using changes in compulsory schooling laws in the US. The estimate of Lleras-Muney (2005) can be thought of as an upperbound, as it is starting from a lower level of education.

Naturally, the life expectancy gap is not eliminated entirely when eliminating the differences in the effectiveness of health investments, since high school graduates still face lower labor productivity, unequal access to health insurance, and different initial conditions with respect to health. We explore these sources of heterogeneity in what follows.

6.2 Income Differences

In order to assess the effect of income inequality on the gradients in health and life expectancy, we eliminate the exogenous education premium in earnings. We do this by raising high school to the level of college. In so doing, we are reducing, but not eliminating, income inequality, since labor productivity is endogenous and dependent on the level of health. However, we consider this exercise informative regarding the effect of income on the incentives to invest in health. In response, the pecuniary and non-pecuniary health investments of high school graduates increase substantially, and the life expectancy gap drops by 0.9 years (see Figure 14). While substantial, the reduction in the life expectancy gap is more modest than that from shutting down the gradient in the effectiveness of health investments.

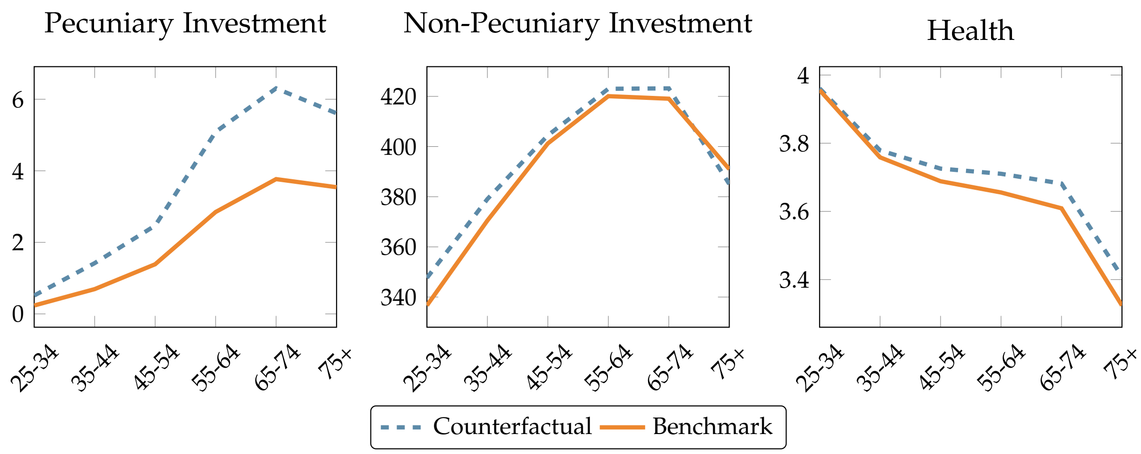

FIGURE 14: ELIMINATING EDUCATION PREMIUM IN EARNINGS

Notes: Pecuniary and non-pecuniary health investments and level of health of high school graduates when eliminating the education premium in earnings.
Source: Simulation results.

It is not surprising that agents increase pecuniary investments in health, when they have more resources to do so. However, agents also increase non-pecuniary investments in health, despite the fact that higher earnings increases the opportunity cost of spending time in health promoting activities. The reason for the increase in both pecuniary and non-pecuniary investments is that health is a luxury good in our model. An increase in average income increases the average level of consumption. This causes the marginal utility of consumption to fall faster than the marginal utility of health[24], and, since life expectancy is endogenous, agents invest in their health in order to increase the number of periods that they derive utility from[25].

6.3 Differences in Initial Level of Health

In the benchmark model, the initial level of health varies with educational attainment. In this exercise, we eliminate these differences over education by assuming that high school graduates draw their initial health from the same distribution as college graduates. This has a sizeable effect in our model. The life expectancy gap narrows by roughly 0.9 years. This despite the fact that the effects on pecuniary and non-pecuniary investment are negligible, and in fact non-pecuniary investment declines slightly relative to the benchmark economy (see Figure 15).

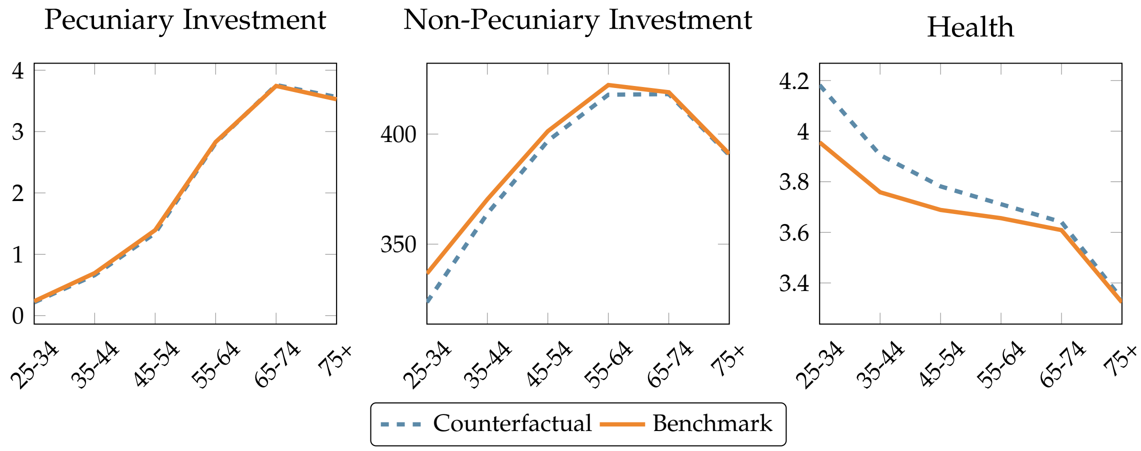

FIGURE 15: ELIMINATING EDUCATION DIFFERENCES IN INITIAL HEALTH

Notes: Pecuniary and non-pecuniary health investments and level of health of high school graduates when eliminating education differences in initial health.
Source: Simulation results.

The improvement in the initial health of high school graduates has a persistent effect in our model, since healthier individuals face smaller health shocks. This is consistent with the empirical literature, which finds strong links between childhood (Schiman, Kaestner and Sasso,

[24]In our framework, the CRRA coefficient of consumption is larger compared to the CRRA coefficient of health, as in Hall and Jones (2007). The intuition behind this parameterization is that, as agents become richer and increase their consumption, they shift relatively more resources towards improving their quality of life.

[25]The effect of income on consumption and health investment in models with endogenous life expectancy has been studied extensively in the literature, see, e.g., Zhao (2014) and Halliday et al. (2017)

2017) and even fetal (Almond and Currie, 2011) health and adult health.

7 Universal Health Insurance Coverage

In this section, we study the effects of a Medicare-for-all type policy on health investments, health, life expectancy, and welfare. Our implementation of universal health insurance is one where the government covers a uniform fraction of total healthcare spending, and all agents pay the Medicare health insurance premium. The private health insurance market is eliminated. We consider four alternative budget neutral financing mechanisms: (i) a proportional increase in the income tax schedule, (ii) an increase in the progressivity of the income tax schedule, (iii) an increase in the Medicare premium, and (iv) a decrease in the coinsurance rate.

Recall that we use the progressive income tax function from Guner et al. (2014):

$$\tau\left(y_j\right) = 1 - \tau_0 y_j^{\varphi} \tag{18}$$

where the tax is a function of the agent's income, expressed in multiples of the agents' mean income y_j, and τ_0 controls the scale and φ the degree of progressivity of the tax function. Thus, when proportionally increasing the income tax rate, we adjust τ_0. In the increased tax progressivity scenario, we adjust both τ_0 and φ in order to balance the government budget by increasing the progressivity of the tax schedule without reducing the income tax level of low income individuals[26].

These policy exercises allow us to study the effects of improved access to healthcare on inequality in health and life expectancy. When health insurance becomes more accessible, the effective price of preventive medical spending goes down. Simultaneously, a Medicare-for-all type policy eliminates the uncertainty with respect to health insurance coverage[27] and reduces the effective cost of curative medical spending. Universal health insurance can, therefore, re-

[26] Adjusting only φ tilts the tax schedule, resulting in higher tax rates for individuals with above average income and substantially lower ones for individuals with below average income. This would make our results hard to interpret. To circumvent this issue, we adjust the tax schedule by estimating the ϵ that balances the government budget in $1 - (\tau_0 + \varepsilon)\, y_j^{\varphi+\varepsilon}$. The income tax schedule becomes more progressive, yet the reduction in the income tax rate for low income individuals is negligible.

[27] Recall that, in our model, agents who do not already hold GHI, face uncertainty every period and the PHI premium is conditional on the expected healthcare spending of each individual. Hence, the expected magnitude of the health insurance premium is health dependent.

duce the incentives to invest in health in order to avoid the high curative costs associated with poor health. Furthermore, agents in our model have an additional margin for improving their health, namely non-pecuniary investment. Agents can substitute pecuniary investment for non-pecuniary investment due to the lower effective price of the former, or increase non-pecuniary investment if the expected level of consumption is higher due to lower medical expenditure shocks[28]. Ex ante, the overall effects of a Medicare-for-all type policy are ambiguous, and we need a structural model to assess them.

7.1 Results

We find that the effects of a Medicare-for-all type policy vary considerably depending on the mechanism used to finance it; the results are summarized in Table 9. The only implementation that significantly improves the welfare of agents *and* narrows the gap in life expectancy between high school and college graduates is the one where the policy is financed by an increase in the progressivity of the income tax schedule.

The change in income tax schedules is plotted in Figure 16. In this scenario, Medicare covers 73% of all healthcare costs. This is the same coinsurance rate as in the benchmark, but with coverage extended to the whole population.

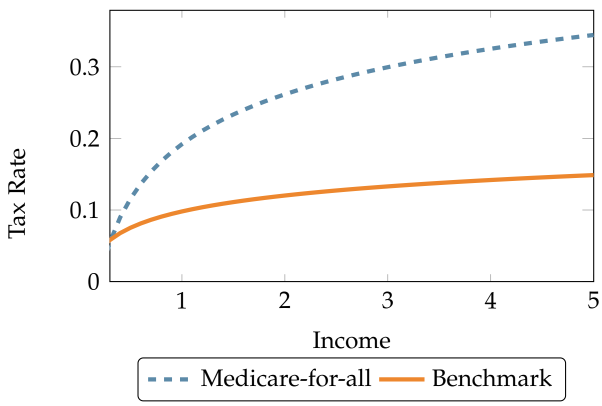

FIGURE 16: INCOME TAX FUNCTION: BENCHMARK VS. INCREASED PROGRESSIVITY SCENARIO

Notes: Income tax schedule when Medicare expansion financed through increase in income tax progressivity.
Source: Benchmark tax function from Guner et al. (2014), updated tax schedule based on simulation results.

Figure 17) plots the changes in pecuniary and non-pecuniary investment as well as health

[28]Recall from the previous section that income and consumption play an important role in determining the willingness to pay for improvements in the quality and quantity of life.

following the Medicare expansion which is funded through increased tax progressivity. High school graduates have on average lower income than college graduates due to both productivity and health differences, and are thus more likely to face a less sharp increase in the income tax rate after the reform. Moreover, high school graduates are more likely to benefit from the expansion of public health insurance coverage, since they are less likely to receive a GHI offer in the benchmark economy. As a result, high school graduates increase pecuniary investment in health after the Medicare expansion. The Medicare expansion results in improved health and higher life expectancy with the latter increasing by 0.61 years. The effect on college graduates is qualitatively similar, but smaller in magnitude. Pecuniary investment rises substantially, but non-pecuniary investment in fact declines somewhat. Average life expectancy of college graduates rises by 0.33 years. Despite the small gains in life expectancy, the welfare gains are large, 12.9% and 7.5% of equivalent consumption for high school and college graduates, respectively. This is largely driven by the change in the progressivity of the income tax schedule and the elimination of health insurance status uncertainty.

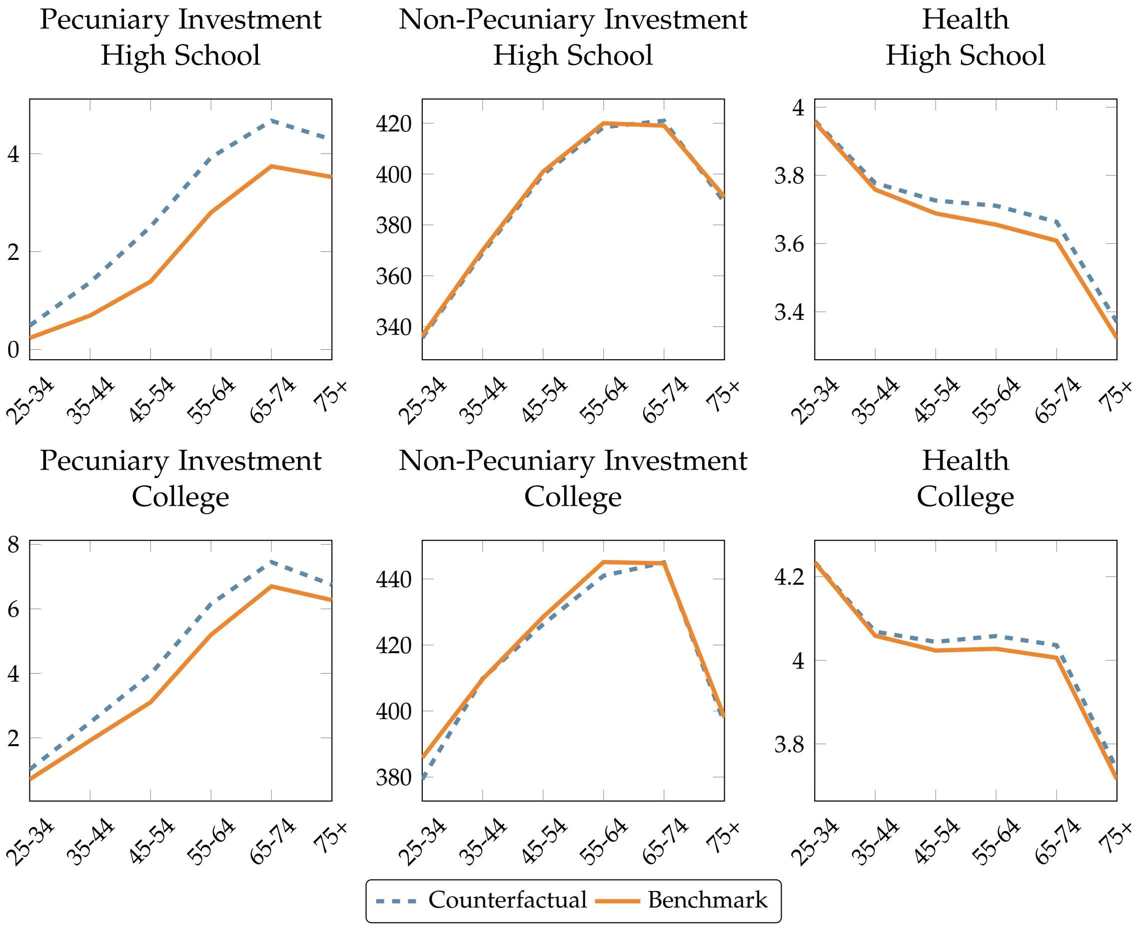

Figure 17: Results for Medicare Expansion Funded Through Increase in Income Tax Progressivity

Notes: Pecuniary and non-pecuniary health investments and health of high school and college graduates when Medicare expansion financed by increase in income tax progressivity.
Source: Simulation results.

When the Medicare-for-all type policy is funded with less progressive mechanisms, the effects on life expectancy and welfare are either negligible or negative.[29] The scenario where the income tax schedule is increased proportionally results in an increase in life expectancy of 0.04 years for high school graduates and a reduction of 0.01 years for college graduates. In terms of welfare, high school graduates lose 2.98% and college graduates 3.49% of equivalent consumption. This is mainly driven by lower disposable income among lower earners. An increase in the health insurance premium has a small negative effect on the life expectancy of high school graduates (0.02 years) and a marginal positive effect on college graduates (0.05 years), but negative welfare effects, -4.93% and -2.26% for high school and college graduates, respectively. The effects on life expectancy and welfare are quantitatively and qualitatively

[29] The effects on pecuniary and non-pecuniary health investment and health can be found in the Appendix.

similar to an increase in the income tax level. However, the negative welfare effects of the uniform increase in the Medicare premium are larger for low educated individuals. The increase in the Medicare premium is the least distortionary, but the most regressive, affecting low educated individuals that have, on average, lower income.

Table 9: Life Expectancy and Welfare Effects of Medicare Expansion Under Alternative Financing Mechanisms

Policy	High School		College	
	Life Expectancy	CEV	Life Expectancy	CEV
Income Tax Progressivity	0.61	12.08%	0.33	7.51%
Income Tax Level	0.04	-2.98 %	-0.01	-3.49%
Premium	-0.02	-4.93%	0.05	-2.26%
Coinsurance	-0.52	0.83%	-0.57	0.29%

Notes: Change in life expectancy (years) and welfare (%) from Medicare expansion realtive to benchmark under alternative funding scenarios: (i) increase in income tax progressivity, (ii) increase in income tax level, (iii) increase in Medicare premium and (iv) decrease in coinsurance rate.

Of the considered funding options, the reduction in the coinsurance rate has the largest negative effect on life expectancy. In this scenario, all agents are insured, but the government covers a lower fraction of medical spending than under the benchmark Medicare plan. This exercise stands out because it focuses on cost containment rather than increasing the resources devoted to public healthcare. The intuition behind this exercise is that the government can reduce the share of treatment costs (or the number of treatments) that are covered under the Medicare-for-all type of policy[30] in order to reduce the total cost of the policy reform. The fall in the coinsurance rate is sharp. In order to balance the government budget, the Medicare coinsurance rate drops from 73% to 54%. This has differential effects on individuals depending on their health insurance status. A substantial share of individuals with GHI in the benchmark are now worse off, since they face a higher effective price of pecuniary investments in health and curative medical spending, while previously uninsured agents obtain coverage and face a lower (yet still high) effective price. The incentives to invest non-pecuniary resources in health are similarly ambiguous. On the one hand, agents that were already insured have an incentive to substitute pecuniary with non-pecuniary investments. On the other hand, they have an overall higher incentive to invest in their health because the out-of-pocket curative

[30] For example, in the U.K., where the government provides universal health insurance coverage, the National Institute of Health Care Excellence (NICE) advises the NHS regarding which treatments are cost effective and should be covered by the NHS. Similar cost containment policies are implemented in other countries.

medical spending shocks are larger. Finally, large curative medical spending shocks reduce the disposable income of the agents, and subsequently their willingness to invest in the quality and quantity of life. We find that, on aggregate, adjusting the coinsurance rate negatively affects pecuniary investment in health, and subsequently health and life expectancy.

In sum, in the benchmark economy, the government covers three quarters of the aggregate healthcare spending of agents aged 65 and older and provides Medicaid to individuals with low income (or those facing curative medical expenditures that are greater than their disposable income). The majority of individuals below age 65 are covered by GHI or PHI. Extending health insurance coverage to the entire population is a large and expensive policy reform. We find that such a reform has negative implications, especially for the low educated, unless the financing mechanism is progressive. Moreover, even when the funding mechanism is progressive, eliminating inequality in access to health insurance has only a small effect on the life expectancy gap between high school and college graduates. This result is consistent with cross-country evidence, which documents comparable life expectancy gaps in countries with universal health insurance coverage, such as the U.K. (Bueren et al., 2018).

8 Conclusions

In this paper, we study the education gradients in health and life expectancy in the U.S.. Using data from the MEPS and the ATUS, we document that low educated individuals spend less on preventive medical spending and invest less time in health promoting activities for every level of health.

To rationalize the gradients in health investments and life expectancy, we develop a structural model where heterogeneous agents make decisions with respect to pecuniary and non-pecuniary health investments. Our results suggest that the lion's share of the life expectancy gradient can be explained by differences in the effectiveness of health investments, income inequality, and initial health conditions. We also study the effects of a Medicare-for-all type policy on life expectancy and welfare. We find that, at best, universal health insurance coverage has a modest effect on the education gap in life expectancy, and can even have adverse effects on life expectancy and welfare, depending on the progressivity of the financing mechanism.

This paper is an important step in understanding the driving forces behind health and life expectancy inequality and how government policies can affect said inequality. However, there are factors that are not considered in this paper and warrant further research. For example, we do not study the effects of universal public health insurance coverage on the private insurance market and the cost of medical treatment.

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Appendices

A Estimation Results

A.1 Health Shocks

Table A1: Regression Results: Health Shock

	Dependent variable:					
	Health Shock					
	Bottom 25%	25-50	50-75	Top 25%	Bottom 25%	25-50
Age	-0.002^{***}	0.001^{***}	0.006^{***}	-0.002^{***}	0.001^{***}	0.004^{***}
	(0.0002)	(0.001)	(0.002)	(0.0002)	(0.0004)	(0.001)
Age Squared	0.0002^{***}	0.0003^{***}	0.0002^{***}	0.0002^{***}	0.0003^{***}	0.0003^{***}
	(0.00001)	(0.00002)	(0.00005)	(0.00001)	(0.00001)	(0.00004)
Health	0.036	0.175^{***}	0.154	0.115^{***}	0.278^{***}	-0.074
	(0.033)	(0.040)	(0.098)	(0.032)	(0.065)	(0.109)
Health Squared	-0.038^{*}	-0.221^{***}	-0.193^{***}	-0.085^{***}	-0.287^{***}	-0.023
	(0.021)	(0.027)	(0.066)	(0.020)	(0.043)	(0.073)
Constant	0.007	0.128^{***}	0.362^{***}	-0.023^{*}	0.088^{***}	0.434^{***}
	(0.013)	(0.017)	(0.042)	(0.013)	(0.021)	(0.038)
Observations	27,527	20,847	2,319	25,551	19,760	1,941
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A2: Regression Results: Medical Spending Shock

	Dependent variable:					
	Medical Spending Shock					
	HS Bottom 25%	HS 25-50	HS 50-75	HS Top 25%	C Bottom 25%	C 25-50
Age	−0.0002	0.045***	0.260**	0.001**	0.027***	0.367***
	(0.001)	(0.003)	(0.109)	(0.0004)	(0.002)	(0.057)
Age Squared	0.0004***	0.0005***	−0.005	0.0004***	0.001***	−0.006***
	(0.00004)	(0.0001)	(0.003)	(0.00002)	(0.0001)	(0.002)
Health	0.238	−1.418***	−18.429***	0.447**	−1.583***	1.140
	(0.160)	(0.307)	(6.205)	(0.212)	(0.369)	(2.708)
Health Squared	−0.243**	0.230	13.433***	−0.346***	0.424*	−1.305
	(0.106)	(0.191)	(4.870)	(0.132)	(0.247)	(2.125)
Constant	0.007	1.265***	9.391***	−0.091	1.241***	0.825
	(0.055)	(0.125)	(2.316)	(0.083)	(0.136)	(0.785)
Observations	25,357	22,805	2,543	23,635	21,253	2,370
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A3: Regression Results: GHI Offer

	Dependent variable:
	GHI Offer
	Probit
Age	0.056***
	(0.006)
Age Squared	−0.004***
	(0.0003)
College Graduate	0.500***
	(0.015)
Constant	0.221***
	(0.027)
Observations	75,567
Note:	*p<0.1; **p<0.05; ***p<0.01

A.2 Curative Medical Spending Shocks

A.3 Health Insurance

A.4 Labor Productivity

Table A4: Labour Income processes

	(1) Log Income
Age	0.135***
	(330.45)
Age Squared	-0.00577***
	(-194.97)
Health	1.172**
	(14.38)
Health Squared	-0.534**
	(-18.39)
HS Graduate	0.346**
	(18.13)
College Graduate	0.845***
	(84.59)
Constant	0.000512
	(0.01)
Observations	94119

t statistics in parentheses
Source: PSID
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B Medicare-for-all

Here we present the simulation results and figures for the remaining exercises with respect to universal health insurance coverage. In particular, Medicare-for-all financed by an increase in the income tax level, the Medicare premium and cost containment with a reduction in the coinsurance rate.

B.1 Increase in Income Tax Level

Consider an expansion of Medicare to all individuals in the economy financed by an increase in the income tax level. The government keeps the same coinsurance rate as in the current implementation of Medicare of around 73%, meaning that the government covers almost three quarters of the total preventive and curative medical spending. Recall that we approximate the progressive income tax as in Guner et al. (2014):

$$\tau\left(y_j\right) = 1 - \tau_0 y_j^{\varphi} \tag{19}$$

where the income tax is a function of the agent's income expressed in terms of multiples of the agents' mean income y_j, τ_0 controls the scale and φ the degree of progressivity. In this quantitative exercise we allow τ_0 to adjust in order to keep the government balance fixed, changing the scale of the income tax structure. Figure 18 shows the average income tax rate for different levels of income in the benchmark case and after the implementation of Medicare-for-all.

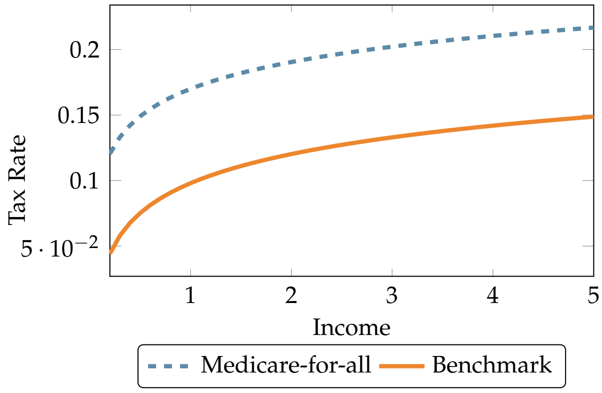

FIGURE 18: PREVENTIVE, CURATIVE AND AGGREGATE MEDICAL SPENDING

Notes: Preventive and curative medical spending by age and education. Preventive medical spending refers to the aggregate health care spending that the individuals choose to invest in their health and curative medical spending refers to the medical spending shocks that the agents need to pay in order to survive to the next period.

Source: Simulation results.

The increase in the income tax level is sharp since the implementation of universal health insurance coverage is an expensive policy reform.

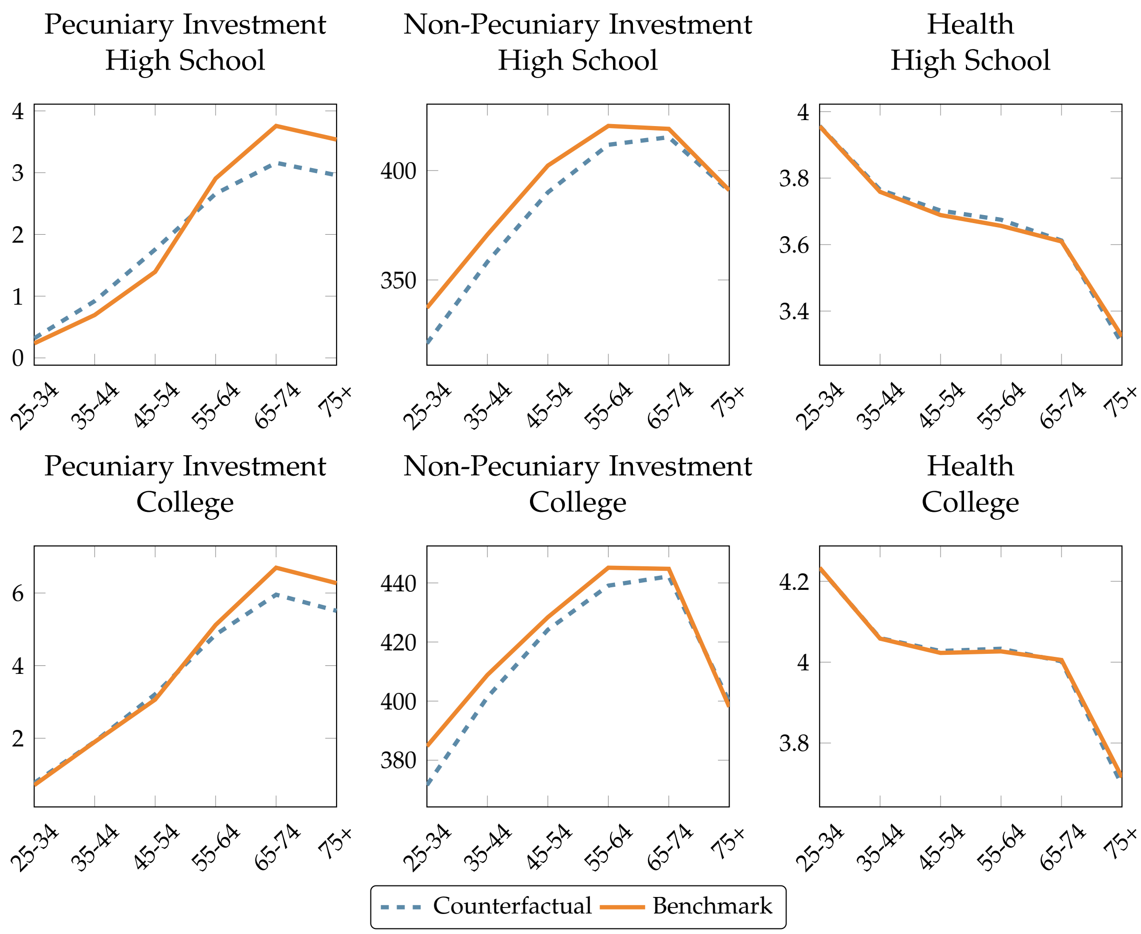

FIGURE 19: PECUNIARY AND NON-PECUNIARY INVESTMENTS, AND HEALTH

Notes: Pecuniary and non-pecuniary investments and health of high school graduates and college graduates for the benchmark simulation and the Medicare expansion financed by an increase in the income tax level.

Source: Simulation results.

Pecuniary and non-pecuniary investments in health decline for both older high school and college graduates (Figure 19) since there is no substantial gain in terms of health insurance for retired workers who are already covered by Medicare. Pecuniary investment increases for high school graduates during working years since they are fully covered by health insurance, eliminating the uncertainty of GHI and PHI. Non-pecuniary investment falls because the average relative price of pecuniary investment is lower after the policy reform and agents substitute non-pecuniary with pecuniary investments. In addition, agents have less disposable income, which reduces the incentives of the agents to invest in the quality and quantity of life. This has adverse effects on health and life expectancy, eliminating any life expectancy gains from the increase in pecuniary investment in health. Life expectancy increases by only 0.04 years for high school graduates while it falls for by 0.01 for college graduates. Furthermore, the reduction in disposable income has large negative welfare effects; high school graduates lose 2.98% and college graduates 3.49% of equivalent consumption.

B.2 Increase in Medicare Premium

The Medicare-for-all implementation with an increase in the Medicare premium is essentially an adjustment of a lump-sum tax that doesn't distort labor supply decisions.

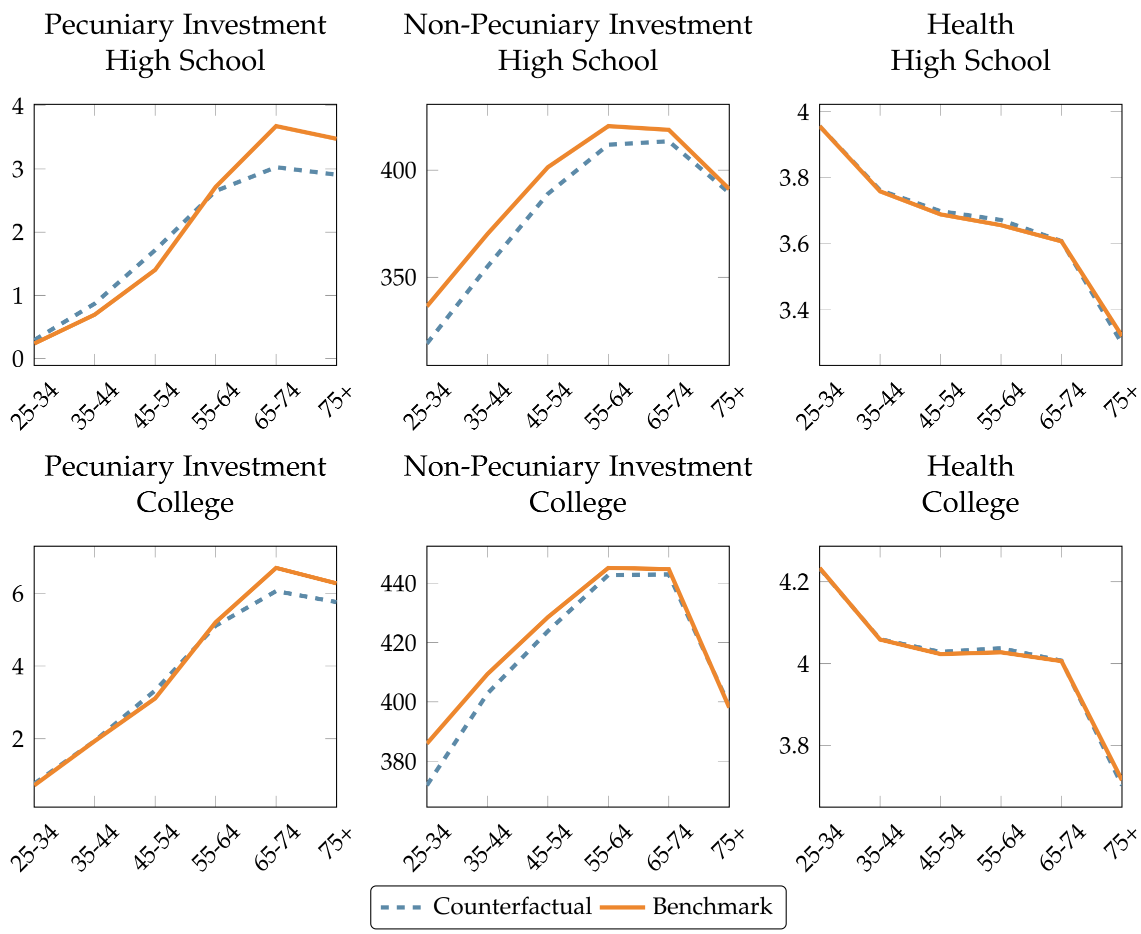

FIGURE 20: PREVENTIVE, CURATIVE, AND AGGREGATE MEDICAL SPENDING

Notes: Pecuniary and non-pecuniary investments and health of high school graduates and college graduates for the benchmark simulation and the Medicare expansion financed by an increase in the Medicare Premium.

Source: Simulation results.

B.3 Reduction in Coinsurance Rate

We consider an expansion of public health insurance that ensures a constant government budget by reducing the Medicare coinsurance rate. Essentially, all agents are covered, but the government covers a lower fraction of medical spending compared to the current implementation of Medicare. This exercise stands out because it focuses on cost containment instead of financing the increase of the medical spending share that is covered by the government. The intuition behind this exercise is that the government can adjust which treatments are covered under the Medicare-for-all type of policy[31], and what fraction of the covered treatments is subsidized in order to reduce the total cost of the policy reform.

[31]For example, in the U.K. where the government provides universal health insurance coverage the National Institute of Health Care Excellence (NICE) advises the NHS regarding which treatments are cost effective and should be covered by the NHS. Similar cost containment policies are implemented in other countries.

The fall in the coinsurance rate is sharp. In order to keep the government budget constant, the Medicare coinsurance rate drops from 73% to 54%.

Pecuniary and non-pecuniary investments in health fall both for high school graduates and college graduates (Figure 21), with adverse effects on health and life expectancy.

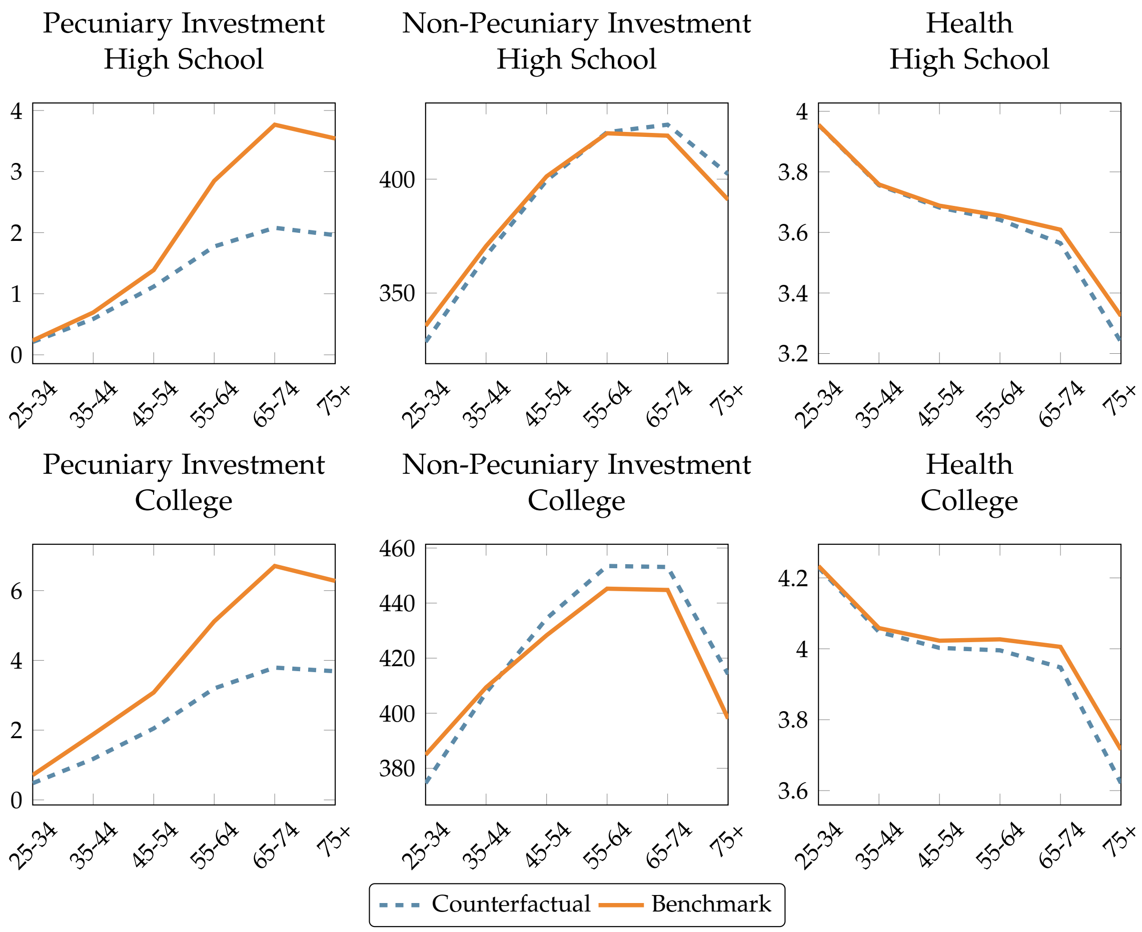

FIGURE 21: PECUNIARY AND NON-PECUNIARY INVESTMENTS, AND HEALTH

Notes: Pecuniary and non-pecuniary investments and health of high school graduates and college graduates for the benchmark simulation and the Medicare expansion accompanied by a reduction in the coinsurance rate.

Source: Simulation results.

The fall in preventive medical spending is not surprising. Despite the universal health insurance coverage and the elimination of health insurance uncertainty, the average coinsurance rate is lower, increasing the effective price of preventive medical spending. Overall, life expectancy for high school and college graduates falls by 0.99 and 1.06 years, respectively, with a fall in CEV of 0.68% and 1.31%, respectively.

B.4 Disability Weights

Table A5: Disability Weights

Description	Weight	Description	Weight
Tuberculosis	0.23	Other and ill-defined cerebrovascular disease	0.61
Bacterial infection; unspecified site	0.04	Transient cerebral ischemia	0.61
HIV infection	0.57	Late effects of cerebrovascular disease	0.61
Hepatitis	0.08	Peripheral and visceral atherosclerosis	0.29
Viral infection	0.01	Aortic; peripheral; and visceral artery aneurysms	0.29
Other infections; including parasitic	0.02	Aortic and peripheral arterial embolism or thrombosis	0.29
Sexually transmitted infections (not HIV or hepatitis)	0.07	Other circulatory disease	0.13
Cancer of head and neck	0.2	Phlebitis; thrombophlebitis and thromboembolism	0.13
Cancer of stomach	0.33	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	0.04
Cancer of colon	0.22	Influenza	0.01
Cancer of rectum and anus	0.22	Chronic obstructive pulmonary disease and bronchiectasis	0.23
Cancer of liver and intrahepatic bile duct	0.2	Asthma	0.23
Cancer of pancreas	0.2	Aspiration pneumonitis; food/vomitus	0.23
Cancer of bronchus; lung	0.43	Respiratory failure; insufficiency; arrest (adult)	0.23
Cancer of bone and connective tissue	0.06	Lung disease due to external agents	0.04
Melanomas of skin	0.06	Other lower respiratory disease	0.04
Other non-epithelial cancer of skin	0.06	Intestinal infection	0.02
Cancer of breast	0.27	Gastroduodenal ulcer (except hemorrhage)	0.02
Cancer of uterus	0.1	Gastritis and duodenitis	0.02
Cancer of cervix	0.08	Appendicitis and other appendiceal conditions	0.46
Cancer of ovary	0.1	Regional enteritis and ulcerative colitis	0.02
Cancer of other female genital organs	0.1	Intestinal obstruction without hernia	0.02
Cancer of prostate	0.34	Diverticulosis and diverticulitis	0.2
Cancer of testis	0.09	Peritonitis and intestinal abscess	0.2
Cancer of kidney and renal pelvis	0.09	Nephritis; nephrosis; renal sclerosis	0.09
Cancer of brain and nervous system	0.09	Acute and unspecified renal failure	0.09
Cancer of thyroid	0.09	Chronic renal failure	0.1
Hodgkin's disease	0.06	Urinary tract infections	0.01
Non-Hodgkin's lymphoma	0.31	Hyperplasia of prostate	0.04
Leukemias	0.09	Inflammatory conditions of male genital organs	0.33
Cancer; other and unspecified primary	0.09	Endometriosis	0.1
Secondary malignancies	0.75	Prolapse of female genital organs	0.1
Malignant neoplasm without specification of site	0.09	Ovarian cyst	0.1
Neoplasms of unspecified nature or uncertain behavior	0.09	Female infertility	0.11
Maintenance chemotherapy; radiotherapy	0.09	Ectopic pregnancy	0.55
Benign neoplasm of uterus	0.09	Skin and subcutaneous tissue infections	0.07
Other and unspecified benign neoplasm	0.09	Other inflammatory condition of skin	0.07
Diabetes mellitus without complication	0.2	Chronic ulcer of skin	0.07
Diabetes mellitus with complications	0.2	Other skin disorders	0.07
Nutritional deficiencies	0.03	Rheumatoid arthritis and related disease	0.53
Gout and other crystal arthropathies	0.13	Osteoarthritis	0.19
Deficiency and other anemia	0.05	Joint disorders and dislocations; trauma-related	0.07
Sickle cell anemia	0.05	Fracture of neck of femur (hip)	0.19
Meningitis (except that caused by tuberculosis or sexually transmitted disease)	0.31	Spinal cord injury	0.73
Parkinson's disease	0.68	Skull and face fractures	0.43
Multiple sclerosis	0.53	Fracture of upper limb	0.19
Paralysis	0.57	Fracture of lower limb	0.19
Epilepsy; convulsions	0.11	Other fractures	0.19
Headache; including migraine	0.03	Sprains and strains	0.06
Cataract	0.1	Intracranial injury	0.36
Retinal detachments; defects; vascular occlusion; and retinopathy	0.1	Crushing injury or internal injury	0.22
Glaucoma	0.1	Open wounds of head; neck; and trunk	0.17
Blindness and vision defects	0.1	Open wounds of extremities	0.17
Otitis media and related conditions	0.02	Superficial injury; contusion	0.17
Other ear and sense organ disorders	0.07	Burns	0.16
Other nervous system disorders	0.5	Poisoning by other medications and drugs	0.17
Heart valve disorders	0.13	Poisoning by nonmedicinal substances	0.17
Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or	0.32	Other injuries and conditions due to external causes	0.17
Essential hypertension	0.25	Adjustment disorder	0.02
Hypertension with complications and secondary hypertension	0.25	Anxiety disorder	0.17
Acute myocardial infarction	0.15	Attention-deficit, conduct, and disruptive behavior disorder	0.17
Coronary atherosclerosis and other heart disease	0.29	Delirium, dementia, and amnestic and other cognitive disorders	0.71
Pulmonary heart disease	0.13	Developmental disorders	0.02
Other and ill-defined heart disease	0.13	Impulse control disorders, NEC	0.13
Conduction disorders	0.13	Mood disorders	0.23
Cardiac dysrhythmias	0.13	Personality disorders	0.66
Cardiac arrest and ventricular fibrillation	0.15	Schizophrenia and other psychotic disorders	0.66
Congestive heart failure; nonhypertensive	0.15	Alcohol-related disorders	0.55
Acute cerebrovascular disease	0.61	Substance-related disorders	0.55
Occlusion or stenosis of precerebral arteries	0.61	Suicide and intentional self-inflicted injury	0.23