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Medical Consumption over the Life Cycle: Facts from a U.S. Medical Expenditure Panel Survey

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Medical Consumption over the Life Cycle:

Facts from a U.S. Medical Expenditure Panel Survey

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Abstract

In this paper we construct life-cycle profiles of health care spending and financing using data from the Medical Expenditure Panel Survey (MEPS). We separate pure age effects from time and cohort effects by estimating a seminonparametric partial linear model. After controlling for time and cohort effects, we find that medical expenditure age profiles follow an upward trend whereas private insurance take-up profiles over age exhibit a hump-shape. In addition, we find that time effects (i.e. productivity effects, business cycle effects, etc.) dominate cohort effects (i.e. initial condition effects) in size despite the fact that we adjust for inflation in the variables measuring medical expenditures. Health expenditure profiles based on simple inflation adjusted values therefore overpredict the effects of age on health expenditures, especially for agents older than 60.

JEL: I10, I11, C14, C23

Keywords: Health expenditure, life-cycle profiles, partial linear models, pseudo panels, medical expenditure panel survey (MEPS)

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1 Introduction

Spending on medical services represents a significant share of U.S. household spending. The total aggregate spending on health was about 16 percent of GDP in 2009 and is expected to increase to 20 percent of GDP in 2020. Upward trends in health expenditures have been widely observed across all OECD countries over the last few decades. Population ageing has been identified to be one of the driving forces behind this increase. Early studies using cross country data found that the age structure is insignificant in explaining health care expenditures (e.g. Gerdtham and Jönsson (2000)) and that ageing could even contribute to decrease spending on health care as the cost of death is lower at higher ages (e.g. Zweifel, Felder and Meier (1999) and Zweifel, Felder and Werblow (2004)). However, more recent studies find that ageing plays indeed a role in explaining the rise in health spending (e.g. Sheiner (2009) and Baltagi and Moscone (2010)).[1]

Understanding how the ageing process influences the demand for health and, by extension, health care services is therefore important in order to correctly project future increases in aggregate health expenditures. Analyzing life-cycle profiles of medical consumption is an important step towards this goal. In addition, it is important to understand how resources are allocated towards maintaining one's health over the life-cycle in order to assess the effects of health care reform. Despite numerous studies that examine the differences in health expenditures by age groups[2], to the best of our knowledge, there is no study focusing on identifying the pure age effects on health expenditures and health care financing over the life-cycle.

In this paper we conduct an empirical analysis of life-cycle profiles of health care expenditures in the U.S. using data from the Medical Expenditure Panel Survey (MEPS) from $1996-2007$. In addition, we analyze the life-cycle usage patterns of various financial resources that are used for spending on health care. We conduct our analysis in two steps. First we construct age specific health expenditure profiles using the entire cross section of the data for the years 1996 to 2007. We find that medical health expenditures follow a life-cycle pattern as the expenditures for younger age groups are relatively small but exhibit a large variance. Spending increases as individuals age and show less variability within older age groups. Since we pool data from all waves, the calculated spending pattern over the life-cycle contains three components: an age effect, a cohort effect and a

[1] Also compare the competing theories about the effect of ageing on health care expenditures presented in (Zweifel, Breyer and Kifmann, 2009, p. 471).

[2] Compare Fisher (1980), Waldo, Sonnefeld, McKusick and Amett (1989), Cutler and Meara (1998), Cutler and Meara (2001), Meara, White and Cutler (2004), and Hartman, Catlin, Lassman, Cylus and Heffler (2008).

time effect. In order to identify the contribution of the age effect on health spending, we need to control for cohort and time effects. The goal of this paper is to construct life-cycle profiles that contain only average age effects. We therefore apply a seminonparametric partial linear modeling technique, based on Speckman (1988), to re-construct pure age driven life-cycle profiles of health expenditure.[3] This method allows for the separation of the age effect from the cohort and time effects.

Results are as follows: *First*, all health expenditures follow a distinct pattern of an upward trend over the life-cycle. Young individuals spend relatively low levels of their income on medical services while old individuals spend larger amounts on health care. On average, agents in their twenties spend about $2,500 per year on health care whereas older agents in their fifties spend around $5,000 per year. Once agents are older than fifty, their health expenditures start to increase very rapidly. The highest expenditures are incurred by old agents at the end of their life and average around $15,000 per year. *Second*, we observe a hump shaped pattern for the private insurance take-up rates. A large number of young individuals do not buy private health insurance so the insurance take-up ratio is very low at the beginning of the life-cycle of an agent. Then the private health insurance take-up ratio gradually increases with age, peaks at age of 55, and then drops as individuals become eligible for public health insurance at the age of 65. *Third*, the inequality in health expenditures is higher among younger individuals and becomes more evenly distributed as individuals get older. *Fourth*, time effects (i.e. productivity effects, business cycle effects, etc.) dominate cohort effects (i.e. initial condition effects) in size despite the fact that we adjust for inflation in the variables measuring medical expenditures. Health expenditure profiles based on simple inflation adjusted values therefore overpredict the effects of age on health expenditures, especially for agents older than 60. This result can be related to Zweifel, Felder and Meier (1999) and Zweifel, Felder and Werblow (2004) who, after controlling for time-to-death, also find that projections based on current status quo measures overpredict the effect of ageing on health expenditures.

The pure life-cycle profiles of medical consumption and insurance take-up ratios are important for two reasons. *First*, the health economics literature has discussed the effects of age as well as the effects of uncertainty and insurance on the demand for health capital and the demand for health care for a long time but very little empirical evidence about the life-cycle patterns of health, health expenditure, and health financing exists. The life-cycle profiles provided in this paper are an indicator of how age influences the demand for

[3]Fernandez-Villaverde and Krueger (2007) use a similar technique to construct age profiles of consumer durables.

health, medical services, health expenditures and insurance, which can be used to assess the effects of ageing on health spending. *Second*, our empirical analysis of U.S. health expenditure profiles provides an important benchmark for assessing the quantitative implications on the demand for health and health care within the Grossman health capital framework (Grossman (1972a)). Therefore, these profiles serve as a benchmark for the calibration of quantitative macroeconomic models with health capital. Such models are used for understanding how health uncertainty affects the distribution of health capital, health expenditures, and health financing together with non-medical consumption over the life-cycle.[4]

The paper is structured as follows. Section 3 briefly describes the data. Section 4 introduces the estimation procedures. Section 5 reports our results. We conclude in section 6. All tables and figures are presented in the Appendix.

2 Related literature

The stylized facts on life-cycle health profiles documented in our paper are connected to several strands of literature in health economics and macroeconomics.

Grossman (1972a) and Grossman (1972) lay out the theoretical foundations of a model with health capital accumulation and demand for medical services. Grossman argues that since health capital depreciates at age-dependent rates, individuals consume more health care services at higher ages to maintain or improve their health capital. There is an empirical literature based on the Grossman model with emphasis on testing the consumption and investment motives of health capital (see Grossman (2000) for a review). Our paper is related to this empirical health econometrics literature, however, we emphasize the life-cycle (age effect) aspects of the demand for health, medical services and medical financing. An analytical analysis by Muurinen (1982) points out the importance of age effects on the demand for health and health care via age-dependent depreciation rates. The decreasing health status measures in our empirical analysis also hint at accelerating depreciation rates of health capital over the life-cycle as do the upward trends in the presented health expenditure profiles.

[4] Moreover, the difference between the upward shaped profile of medical consumption in this paper and the hump shaped profile of non-medical consumption established in previous studies, raises theoretical questions about whether these two profiles can be reconciled in a model. In other words, it is necessary to construct a model in which the demand for health care, health insurance, consumption, and savings are derived simultaneously from a household utility maximization problem. In related work (see Jung and Tran (2009)) we develop such a quantitative macroeconomic model that can match these distinct life cycle patterns.

Extensions of the original Grossman model incorporate uncertainty of health states and account for heterogeneity in health, demand for health care and wealth (e.g. Dardanoni and Wagstaff (1987), Dardanino and Wagstaff (1990), Selden (1993), Chang (1996) and Picone, Uribe and Wilson (1998)). This literature highlights the joint dynamics of wealth and health and the importance of income effects on health spending and health capital levels. Our work is connected to this literature since the life-cycle profiles that we present here indeed vary significantly across income groups. This implies a connection between the effects of income and health shocks on health spending and health states. In addition, our results also show that heterogeneity in health and health spending varies significantly over age (i.e. inequality decreases as individuals age). This indicates that the higher incidence of health problems at higher ages works as an "equalizer" across different income groups. Also, the availability of public health insurance programs may play a role in reducing uneven access to health care services and therefore evens out health expenditures across income groups.

The health economics literature also emphasizes the need to consider the sources of funding for health care spending (e.g. Meza (1983), Pauly (1983), Manning and Marquis (1996), Liljas (1998), and Nyman (1999)). Our work is related to this literature as it provides empirical evidence for the interaction between health spending and financing and the interaction between different funding sources (e.g. out of pocket financing, private insurance, public insurance, etc.) over the life-cycle. Moreover, the reported hump shape of the private insurance take-up ratio, which is similar to the hump shape of the income profile, implies that the life-cycle income effect and the crowding out effects of public insurance programs influence the choice to buy private health insurance contracts. This hump shape stresses the importance of the age effects on insurance choice and the adverse selection issue in health insurance markets.

Finally, there is a large macroeconomic literature documenting the life-cycle profiles of non-medical consumption (e.g. Carroll and Summers (1991), Deaton (1992), Kotlikoff (2001), Gourinchas and Parker (2002)). Fernandez-Villaverde and Krueger (2007) provide life-cycle profiles of durable non-medical consumption goods. Our work extends this literature by constructing life-cycle profiles of medical consumption goods.

3 Medical expenditure panel survey (MEPS)

We use MEPS data from the years 1996 to 2007. The data is an overlapping rotating panel where an individual is surveyed five times over a two year horizon. Each year contains approximately 20,000 individuals between the age of 20 and 87. The pooled data over all 12 waves contains 240,329 individuals. MEPS data is particularly useful to analyze health expenditures as it contains many variables that allow us to decompose health expenditure into various spending categories. In addition, MEPS does not suffer from an out-of-pocket spending bias like data from the Health and Retirement Survey (HRS) (see the discussion in Hurd and Rohwedder (2009)).

We have to delete some observations in order to be able to construct a balanced pseudo panel. The data cleaning process leaves us with 209,053 individual observations. We present summary statistics of the pooled data in table 1. All dollar values are denominated in 2005 dollars where we have used the consumer price index for all urban consumers (CPI) to deflate income measures and the CPI for medical care to deflate all health care expenditure measures.[5] The sample we work with consists of individuals born between 1921 and 1976, they are between 20 and 85 years old, and we observe them from 1996 to 2007. The majority is female (53.8 percent). A total of 63.1 percent are either married or live with a partner. The average annual wage income is $24,720. The average total income is $30,584. The average years of education is 12.5 years. The sample contains 0.5 percent students.

The fraction of individuals without health insurance is 16.5 percent. Of the insured population 16.4 percent have only public insurance whereas 67.1 percent have private insurance as well.[6] Total average annual health care expenditures are $5,890. Health expenditures are broken down into expenditures incurred in one's home ($232 annual average), prescriptions ($1,234 annual average), inpatient care ($1,892 annual average), emergency room care ($182 annual average), outpatient care ($588 annual average), and office visits with doctors ($1,285 annual average).

Health status measures. Various proxy measures of health capital have been used in empirical studies. The MEPS data provides one such measure, the Short-Form 12 Version 2 (SF-12v2) health index. The SF-12v2 includes twelve health measures about physical and mental health. We report two versions of this index, one for physical health (Physical component summary: pcs) and one for mental health (Mental component summary: mcs). Both measures use the same variables to construct the index but the physical health index puts more weight on variables measuring physical health components and the mental health index puts more weight on variables measuring mental

[5] See the following website for more information about the consumer price indices used: http://data.bls.gov/cgi-bin/surveymost?cu

[6] Some of the individuals with private insurance also have public insurance.

health components (compare Ware, Kosinski and Keller (1996) for further details about this health index). In addition we use self reported health status measures (1. excellent, 2. very good, 3. good, 4. fair, and 5. poor health) and construct a "healthy" index (see panel B in figure 1). An individual is considered to be healthy if the health status measure is either excellent, very good, or good and unhealthy otherwise. This classification is standard in the literature. Our sample consists of 85.4 percent healthy individuals.

4 Estimation procedure

We first start by exploring simple cross sections of the data. Therefore we pool data from all years and average over all age groups. The so created profiles do contain age, cohort (indicated by birth year), and time effects (indicated by calendar year). Due to the linear dependence of age, cohort, and time effects (i.e. if we know two out of the three variables we can infer the third) we cannot simply run a regression of health expenditures on dummy variables of age, cohort, and time as this would result in multicollinearity problems. Some researchers therefore resort to simply control for two out of the three effects, like Fjeldvig (2009). Employing this method is difficult, however, since our dependent variable (health expenditures) has many zero entries. We therefore follow a procedure used in Fernandez-Villaverde and Krueger (2007) that controls for time and cohort effects simultaneously using a more involved estimation technique that requires a pseudo panel and a seminonparametric linear model based on the partial linear model in Härdle, Liang and Gao (2001). These methods are built on results in Speckman (1988) and Deaton (1997).

4.1 Cross section analysis

We first explore simple cross sections of health care expenditures and average over all age groups from 20 to 85. Ideally we would like to estimate regressions with dummy variables for age, year, and cohort like

$$y_{it} = \beta_0 + \sum\nolimits_{j=20}^{85} \alpha_j D_{age_{jit}} + \sum\nolimits_{t=1996}^{2007} \tau_t D_{year_{it}} + \sum\nolimits_{c=1915}^{1984} \gamma_c D_{cohort_{cit}} + \varepsilon_{it}, \quad (1)$$

where y_{it} is the dependent variable (e.g. health expenditures, income, percentage uninsured, percentage insured public, percentage insured private, etc.) for $i = 1, ..., N$, β_0 is a constant (age = 20, $year$ = 1996, $cohort$ = 1 (=born in 1915)), $D_{age_{jit}}$ is a dummy variable equal to unity whenever individual i turns age j at time t, $D_{year_{it}}$ is a dummy variable equal to unity whenever the observation year is equal to t and zero otherwise, and $D_{cohort_{cit}}$ is a dummy variable equal to unity whenever the individual i in year t is from cohort c. Errors are assumed *iid*. As mentioned earlier this regression is problematic due to the linear dependence of the set of dummy variables. If we know the age and birth year (i.e. cohort) we can figure out the calendar year, etc. This produces a collinearity problem. We therefore first simply look at a cross section ignoring year and cohort effects and average the dependent variable over all age groups which is identical to

$$y_{it} = \beta_1 + \sum\nolimits_{j=20}^{85} \alpha_j D_{age_{jit}} + u_{1,it}. \tag{2}$$

4.2 Pseudo panels and partial linear seminonparametric models

Pseudo panel. Our data is not suitable for standard panel estimation methods. Due to the rotating design we can only track an individual for two consecutive years. However, since the surveys are repeated with new individuals joining every year we are able to construct a pseudo panel that follows a cohort from 1996 to 2007. One advantage of the pseudo panel is that it reduces the attrition problem of a standard panel survey, averages out expectations errors, eliminates the need to control for individual effects as it averages across agents of a given birth cohort, and it eliminates the problem of health expenditure entries equal to zero.

In order to construct a balanced pseudo panel we define 12 five-year cohorts starting cohort one with birthyears from 1920 to 1924, cohort two covers birthyears from 1925 to 1929, and finally cohort 12 covers birthyears from 1975 to 1979. We assign as cohort age the age of the oldest member of the cohort, so that all members who are, say, between 75 and 81 years in 2000 are identified to belong to cohort 2, with birthyears between $1925-1929$. We then assign age 81 to this cohort and calculate the average y_c of the dependent variable y across all members of this cohort in year 2000.

As a consequence the pseudo panel consists of 144 observations. Table 3 presents the absolute frequencies for each cohort in each year and table 2 presents summary statistics for the pseudo panel, averaged over all 12 waves (from 1996 to 2007) and over all 12 cohorts.

Partially linear seminonparametric model. We next introduce a procedure that controls for time and cohort effects simultaneously. We use the partial linear model developed in Speckman (1988) and later employed by Fernandez-Villaverde and Krueger

(2007) for consumer durable expenditures over the life-cycle. The procedure rests on the following idea. Since time, cohort and age are perfectly linearly dependent, we use a non-linear transformation of the variable age and write the system as

$$\ln y_{ct} = \beta_0 + m\left(age_{ct}\right) + \sum\nolimits_{t=1996}^{2007} \tau_t D_{year_{it}} + \sum\nolimits_{c=1915}^{1984} \gamma_c D_{cohort_{ct}} + \varepsilon_{ct}, \tag{3}$$

where m is a non-linear transformation of the cohort age in time t denoted as age_{ct}, and $\ln y_{ct}$ is the log transformation of the average of the dependent variable across cohorts.[7] More specifically, Fernandez-Villaverde and Krueger (2007) suggest to use the Nadaraya-Watson estimator of the form

$$\hat{m}\left(age\right) = \frac{\sum\nolimits_{i=1}^{N} \sum\nolimits_{t=1996}^{2007} K_h\left(age - age_{it}\right) \times y_{it}}{\sum\nolimits_{i=1}^{N} \sum\nolimits_{t=1996}^{2007} K_h\left(age - age_{it}\right)}, \tag{4}$$

where

$$K_h\left(u\right) = \frac{0.75}{h}\left(1 - \left(\frac{u}{h}\right)^2\right) \times I\left(\left|\frac{u}{h}\right| \leq 1\right), \tag{5}$$

is an Epanechnikov kernel and h is the bandwidth parameter. Note that the Nadaraya-Watson estimator with a kernel with bandwidth $h = 1$ is identical to simply calculating averages of y per age group, whereas a bandwidth parameter $h > 1$ calculates local averages and smoothes the age profile of y.

In order to simplify the notation we rewrite expression (3) in matrix notation where we summarize the dummy variables in matrix $X_{C\times T, 1+C+T-2}$, where $C = 12$ is the total number of cohorts, and $T = 12$ is the total number of years. We also add a column of ones for the constant. The estimation equation can then be written as

$$y_c = \beta^T X + m\left(age\right) + \varepsilon.$$

We first estimate

$$y_c = m\left(age\right) + \varepsilon,$$

using the Nadaraya-Watson estimator as described above. We next build a smoothing matrix S that fulfills

$$\hat{y}_c = Sy = m\left(age_{ct}\right).$$

[7] Taking logs after averaging introduces an aggregation bias according to Attanasio and Weber (1993) that could be prevented by taking logs before averaging. However, since many individuals do not spend anything on health in any given year, we cannot make the log transformation before the aggregation, unless we are willing to replace the zero entries with arbitrary small positive numbers.

We then transform the system and create partial residual vectors as

$$\tilde{y}_c = (I - S)\, y \text{ and } \tilde{X} - (I - S)\, X.$$

Next we estimate parameter β as

$$\hat{\beta} = \left(\tilde{X}^T \tilde{X}\right)^{-1} \tilde{X}^T \tilde{y}_c.$$

Finally, we use expression $y_c - X\hat{\beta}$ as dependent variable in the kernel smoother function to estimate $\hat{m}\,(age_{ct})$ and transform the predicted (and smoothed values) of y_c back into levels using the exponential function. These predictions are now cleared of cohort and time effects and represent the pure age effects of health expenditure.

5 Results

5.1 Results from cross section analysis

We first present results from a simple cross section analysis over age. We present a measure of health status, total health expenditure and its concentration (Gini coefficient) over age as well as various decompositions by expenditure type, gender, income, and insurance type. We also present a decomposition by financing source.

Health status index as a proxy of health capital. The health economics literature starting with Grossman (1972a) and Grossman (1972), Muurinen (1982) and many others developed the theoretical foundations of a model of health capital accumulation of an individual and from that derived the demand for medical services. This literature argues that health capital depreciates at age-dependent rates so that individuals consume more and more health care services to maintain or improve their health capital over the life-cycle.

We use various measures for health status (our proxies for health capital) to construct health profiles over the life-cycle. We present our results in Panel A in figure 1. We see that both the physical component of the SF-12v2 and the "healthy" index show comparable trends over the life-cycle. Young individuals hold relatively high levels of health capital. The average health status decreases as an individual ages. On the other hand, the mental health component of the SF-12v2 follows a different trend and exhibits an "M" shape. Young individuals (around age 20) and very old individuals (around age 75 and higher) report the lowest mental health status. Interestingly, individuals in the age range between 40 and 55 have lower mental health status than younger cohorts in their thirties and older cohorts in their sixties and could be a reflection of that cohort's dealings with what is commonly referred to as mid-life crisis.

Total health expenditure profile. Figure 2 presents the average and the median of total health expenditure over age in panel A. We observe a pronounced increase of health expenditures as the agents get older. Young individuals consume relatively low levels of medical services whereas old individuals incur larger health expenditures. On average, agents in their twenties spend about $\$2,500$ per year on health care whereas older agents in their fifties spend $\$5,000$ per year. Once agents are older than fifty, their health expenditures start to increase very drastically. The highest expenditures are incurred by old agents at the end of their life and amount to approximately $\$15,000$ per year.

We find that the mean health expenditures are consistently higher than median health expenditures and the gap between mean and median health expenditures get bigger as individuals age. This fact indicates that the averages are likely to be distorted by "outliers" with very high health expenditures (e.g. out of $209,053$ individual observations, there are 14 individuals with annual health expenditures exceeding $\$500,000$, 995 individuals spend more than $\$100,000$, and $3,771$ individuals spend more than $\$50,000$).

In order to get a better sense for the distribution of health expenditures we also plot the Gini coefficient of health expenditure per age group in panel B. We find that the Gini coefficient of health expenditures is very high around 0.8 when agents are younger than 40 and then sharply drops after agents get older. Higher Gini coefficients at younger ages indicate that health expenditures among the young are much more concentrated than health expenditures of the old. As such this is probably driven by relatively rare, but catastrophic health events amongst the young. Lower Gini coefficients at older ages imply that the higher incidence of health problems at higher ages works as an equalizer across individuals. Moreover, it may suggest that the availability of public health insurance programs plays a role in reducing uneven access to health care services and therefore evens out health expenditures differences across different income groups.

Comparing the results from the health expenditure profiles with the health status profiles in figure 1 we find that the two profiles are inversely related over the life-cycle. Exponentially depreciating health capital levels are some of the main causes behind the upward trend in medical consumption over the life-cycle.

Expenditure types. We next investigate which medical services individuals consume over the life-cycle and how the consumption pattern changes as individuals age. We therefore decompose total health expenditures into different expenditure types and present the results of this decomposition in figure 3.

All components follow an almost exponential trend over age. The biggest contributors to the total health expenditure figure are inpatient hospital spending, prescription drugs, doctor office visits, outpatient hospital care, and home care spending. Inpatient hospital services is the most important service category and individuals on average spend more than 50 percent of total health spending on inpatient hospital services. Notably, inpatient hospital spending together with prescription drugs and doctor office visits are major forces behind the sharp increase in health expenditures after age 60. Home care spending is one of the fastest growing components of health expenditures at higher ages and also the one least likely to be covered by traditional health insurance contracts.

Gender specific health expenditure profiles. We next present health expenditure profiles by gender in figure 4. We see that women significantly outspend men over the life-cycle. Only at higher ages (60 and above) can we observe convergence of these spending patterns. Specifically, we find that women between the age of 20 and 40 spend on average 95.6 percent more on health care than men of the same age group. Women between age 40 and 60 spend 23 percent more, and women older than 60 spend as much as men. This fact is consistent with reports in the literature that women outspend men, especially during their prime childbearing years.[8]

This observation is also consistent with self reports of subjective health states by men and women (see figure 5). Women over all age groups report lower physical and mental health status levels than men (i.e. pcs and mcs). In addition, the constructed "healthy" index follows a similar patterns.

Income and health expenditure. To understand how income influences decisions on health and vice versa we break down health expenditures by income quartiles (see figure 6). We find that individuals in the lowest income quartile outspend the others on average in levels when they are younger than 65. The negative correlation between income and health spending also suggests that the group that is more exposed to high health risk is probably also the group with low income and high health care cost. Public health insurance (Medicaid) is another force behind high health expenditure levels of low income groups as it is means-tested. In this sense, this result is not surprising.

[8] Compare publications from the National Women's Law Center at: http://nwlc.org/reformmatters/facts.html

Next we index health expenditures to income over the life-cycle to see how health expenditures are financed. We plot average health expenditures as fraction of average income over age. We find that on average the lowest income group spends vastly more than 100 percent of their income on health on average (see figure 7). This confirms the fact that public health insurance is a main financing instrument for health expenditures of low income groups. Moreover, we find that health expenditure as a fraction of average income sharply increases with age. At the end of the life-cycle, only individuals in the highest income group can finance their health expenditures from their income. Individuals in the third income quartile can barely pay their health care bill out of their income and individuals in the second income quartile are not financially capable to pay the out-of-pocket share of their health care bills after the age of 70.

Insurance and health expenditure. We next present how health insurance status affects health spending. We classify individuals into three groups: individuals without health insurance, individuals with public health insurance only, and individuals with private health insurance (who may also have public health insurance). We report spending profiles of these three groups in figure 8.

We find that the average health expenditure of the uninsured is significantly below the average health expenditure of the insured. This is true for all age groups and the spending gap increases after age sixty. This is a direct result of moral hazard (intensive margin) and access to care (extensive margin). We also see that over the working age from 20 to 65 individuals with public insurance on average outspend individuals with private insurance. This might be the result of adverse selection of high risk types into public insurance pools. In other words, profit-maximizing private health insurance providers screen out high health risk individuals so that many of them end up relying on public health insurance programs.

After agents retire, the spending gap between individuals with public insurance only and individuals with private insurance almost disappears. This is, in all likelihood, the result of Medicare and its high coverage rate (almost 100 percent of individuals older than 65 are covered by Medicare).

Health expenditure by financing source. Financing sources and health spending are connected via the household budget constraint and a household's preferences. When we break down the expenditure patterns by funding source: out-of-pocket, public insurance programs (Medicare and Medicaid), private insurance programs and other insurance programs (see figure 10), we find that out-of-pocket and private insurance are major sources of health care funding for working age individuals. The fraction of health expenditures financed by private insurance and Medicaid decreases over age, whereas the fraction of health expenditures financed by out-of-pocket expenditure increases moderately. We find that around the standard retirement age of 65 there is a big shift in magnitude of financing from private insurance to public insurance. We find the largest increases in the components financed by Medicare, Veteran's benefits, and other State insurance. The latter is again proof of the increasing burden on the public health insurance sector caused by moral hazard and the ageing of the population.

In figure 9 we analyze out-of-pocket health expenditures by gender over age and find that the growth rates over age are more moderate. Insurance and especially insurance at higher ages slows down the growth rates of out-of-pocket health expenditures. On the other hand, the gender gap of out-of-pocket health expenditures persists as the agents get older (different from the gender gap in total health expenditures discussed above). Initially women between the age of 20 and 40 spend on average 84.9 percent more out-of-pocket on health than men of the same age. Women aged 40 to 60 spend 40.5 percent more out-of-pocket and women aged 60 to 80 spend 22.7 percent more out-of-pocket on health than men of the same age. It therefore seems, that insurance widens the gender gap in terms of out-of-pocket health expenditures, which either implies that women are under or men are overinsured.

5.2 Pseudo panels and the decomposition of age, cohort and time effects

The previous analysis is useful as a first summary of health expenditures over the course of life of the average individual. However, averaging over cross sections is too crude a measure as to be able to isolate the pure age effects.[9] We next present pure age effects predicted from partial linear models. We first analyze health expenditures followed by income, the fraction of uninsured, the fraction of publicly insured, and the fraction of privately insured individuals.

Health Expenditures. In figure 11 we report averages of health expenditure per cohort over time, the average over age (the cross section from before, but smoothed), the average over time, and the average over the twelve cohorts. We find that as agents get

[9] We do not control for ageing nor time-to-death effects in the current analysis. In our model, the effect of age is a composite of the effect of calendar age and time-to-death which has been found to be a main explanatory component for health expenditures according to Zweifel, Felder and Meier (1999) and Zweifel, Felder and Werblow (2004).

older their health expenditures increase. We observe the usual patterns such as health expenditures increasing in age, time, and cohort vintage. The older the cohort the higher its health expenditure. However, there is also an interesting effect seen in panel A, where it seems that older cohorts spend less on health expenditure when controlling for age. This could obviously be due to price and time effects.

We next analyze the implications of the time and cohort effects. We report the results of the model prediction from the partial linear model that we described in section 4.2 in the top panel of figure 12. Age profiles that are cleared of time and cohort effects predict lower average health expenditures for each age group than the pure cross sections that include time and cohort effects.

The partial linear modelling technique allows us to extract the time and cohort effects separately, so that we can make statements as to their relative size and importance. Interestingly we find that health expenditure profiles purged of the time effect (and only including the cohort effect) results in the lowest predictions for average health expenditure over age (downward pointing triangles). However, this result is reversed for the very old agents (> 70). The health profile purged of the cohort effect (but including the time effects) results in larger predictions for health expenditures over age (black line with upward pointing triangles) which is again reversed for the very old agents. It is important to note that once both, cohort and time effects are free to "interact" the predictions for health expenditures are the largest as can be seen from the simple cross section (blue line with circles). In other words, health expenditure profiles that are simply based on cross section averaging overpredict the effect of age on health expenditures over the life-cycle despite the fact that inflation has explicitly been taken into account.

Our results hint at the existence of additional factors (additional to age and inflation in the medical sector) that push up health expenditures as individuals age. These factors are summarized as cohort and time effects. Cohort effects (initial condition effects or effects triggered by events before the data collection date) and time effects (effects triggered by events during the data collection process). Cohort effects control for ageing and since ageing contributes to increases in health expenditures, the inclusion of cohort effects will lead to overstating the importance of age itself as an explanatory factor for health spending. Time effects control for events contributing to increases in health expenditures during the collection period of the data and could include business cycle effects (other than inflation, which we control for even in the simple cross section profiles) triggered by changes in government policies, changes in preferences, sectorial changes in the economy and many more during the data collection period from 1996 to 2007.

Robustness. In order to check the robustness of our predictions we use a bootstrap procedure to construct 95 percent confidence bands around our point estimates for health expenditure without time and cohort effects. We create bootstrap samples of size $n = 144$ by drawing from the pseudo-panel with replacement and applying our estimation/projection procedure. We create 500 predictions over the entire age range and then plot the 2.5^{th} percentile and the 97.5^{th} percentile. We report the point predictions of the health expenditure health profile without time and cohort effects but including confidence bounds for the predictions in panel B of figure 12. We see that the confidence bounds track the point estimates from our prediction closely. In addition, we see that age profiles that are cleared of time and cohort effects are significantly lower than simple cross sections for older cohorts (> 60) as here the simple cross section profile (blue line with circles) lies outside the confidence bounds of the partial linear model. For younger cohorts we cannot find a significant difference between simple cross sections and profiles purged of cohort and time effects.

We therefore conclude that time effects dominate cohort effects in size despite the fact that we adjust for medical inflation. Health expenditure profiles based on simple discounted values therefore overpredict the effects of age on health expenditures. Macroeconomic models that attempt to match the life-cycle profile of health care expenditures in the U.S. but do not explicitly model business cycle effects or ageing effects need to take these differences into consideration.

6 Conclusion

In this paper we document stylized facts on medical consumption and financing over the life-cycle. We find an upward trend for medical consumption and a hump-shape pattern for private insurance take-up ratios over the life-cycle controlling for cohort and time effects. We use a seminonparametric partial linear model to isolate the pure age effect on medical consumption and on private health insurance take-up rates. We find that time effects dominate cohort effects in size despite the fact that we adjust for medical inflation. Health expenditure profiles based on simple discounted values of health expenditure therefore overpredict the effects of age on health expenditures.

Our findings raise some interesting theoretical and empirical questions for health economics and macroeconomics. First, the shape of the life-cycle profile for medical consumption is different than the shape of the life-cycle profile for non-medical consumption established in previous studies (e.g. see Gourinchas and Parker (2002) and

Fernandez-Villaverde and Krueger (2007)). The age effect causes health to depreciate faster at higher ages and is one of the main driving forces behind the increases in health expenditures over age. The results indicate that agents are not able to smooth their medical consumption over age. This raises the question about how agents should re-allocate resources using savings or various insurance options in order to smooth non-medical consumption while financing increasing levels of medical consumption over the life-cycle. The former has been analyzed extensively in macroeconomics whereas the latter has been analyzed in health economics and insurance economics.

Medical consumption accounts for a substantial part of consumption (more than 16 percent of GDP in the U.S. in 2009), however, the work horse models of consumption and savings in the macroeconomic literature focus only on explaining the hump-shape of non-medical consumption over the life-cycle (e.g. see Fernandez-Villaverde and Krueger (2007)). This raises the theoretical question about whether a macroeconomic model is able to reconcile these two distinct consumption profiles. In other words, a macroeconomic model with micro-foundations of health capital and demand for health care demand is needed. Dynamic life-cycle heterogeneous agents models that include the ideas of the Grossman human capital model would be natural candidates to address these questions.

Second, the reported hump-shape of the private insurance take-up ratios indicate that young agents with low income are less likely on average to buy private health insurance whereas middle aged agents experiencing a peak in their life-cycle income are more likely to buy insurance. This indicates that many of the uninsured opt out of health insurance markets. Young individuals facing low health risk are less willing to buy private health insurance while older individuals are more willing (or able) to buy health insurance. These facts imply that we need to study the decision to buy health insurance together with consumption, labor and savings decisions within a more comprehensive life-cycle model.

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7 Appendix

Table 1: Summary statistics of the pooled data 1996 to 2007

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
Birth year	1953.915	(14.495)	1921	1976	209053
year	2001.664	(3.375)	1996	2007	209053
Age	47.749	(14.759)	20	85	209053
Female	0.538	(0.499)	0	1	209053
Married/Partnered	0.631	(0.483)	0	1	209053
Black	0.081	(0.272)	0	1	209053
Wage income (in $1,000)	24.72	(29.061)	0	632.951	209053
Total income (in $1,000)	30.583	(30.133)	0	658.615	209053
Years of education	12.513	(3.154)	1	17	205604
Student	0.005	(0.072)	0	1	209053
Healthy	0.854	(0.353)	0	1	207954
Uninsured	0.165	(0.371)	0	1	209053
Public health insurance	0.164	(0.37)	0	1	209053
Private health insurance	0.671	(0.47)	0	1	209053
Total health expenditures (in $1,000)	5.89	(16.491)	0	1697.831	209053
Health expenditues: Home	0.232	(3.442)	0	521.416	209053
Health expenditues: Other	0.476	(1.427)	0	97.717	209053
Health expenditues: Prescriptions	1.234	(3.158)	0	351.836	209053
Health expenditues: Inpatient	1.892	(12.23)	0	1697.685	209053
Health expenditues: Emergency room	0.182	(1.089)	0	93.822	209053
Health expenditues: Outpatient/hospital	0.588	(3.361)	0	372.817	209053
Health expenditues: Doctor/office	1.285	(4.354)	0	555.811	209053
Source: Out-of-pocket	1.074	(2.457)	0	180.467	209053
Source: Medicare	1.346	(8.257)	0	543.877	209053
Source: Medicaid	0.645	(5.482)	0	671.98	209053
Source: Private insurance	2.25	(9.765)	0	811.759	209053
Source: Veteran's benefits	0.149	(2.864)	0	829.527	209053
Source: CHAMPUS	0.005	(0.315)	0	88.633	209053
Source: Tricare	0.036	(0.962)	0	166.781	209053
Source: Federal insurance	0.023	(0.605)	0	71.460	209053
Source: State insurance	0.044	(1.166)	0	196.773	209053
Source: Worker's compensation	0.109	(3.227)	0	1240.816	209053
Source: Other	0.059	(1.332)	0	309.533	209053
Health index physical components	47.749	(12.803)	-9	76.13	131671
Health index mental componenets	49.622	(12.042)	-9.169	77.370	131671

Table 2: Summary statistics of the pseudo panel data 1996 to 2007

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
(mean) agec	53	(17.664)	20	86	144
(mean) female	0.543	(0.029)	0.496	0.665	144
(mean) married	0.605	(0.113)	0.111	0.748	144
(mean) black	0.074	(0.075)	0	0.181	144
(mean) wageIncome	21.06	(10.656)	2.346	34.191	144
(mean) totalIncome	28.639	(6.275)	9.604	38.357	144
(mean) yearEducation	12.355	(0.543)	10.982	13.13	144
(mean) student	0.012	(0.057)	0	0.444	144
(mean) healthy	0.839	(0.08)	0.699	0.976	144
(mean) uninsured	0.147	(0.097)	0.001	0.351	144
(mean) public_insurance	0.207	(0.156)	0.059	0.579	144
(mean) private_insurance	0.647	(0.095)	0.42	0.793	144
(mean) healthExpenditure	6.808	(4.149)	1.749	16.857	144
(mean) homeHealthExp	0.33	(0.453)	0	2.291	144
(mean) otherHealthExp	0.503	(0.177)	0.162	0.929	144
(mean) prescriptExp	1.41	(1.009)	0.152	3.583	144
(mean) inpatientExp	2.322	(1.637)	0.636	6.958	144
(mean) emergencyRoomExp	0.186	(0.066)	0.091	0.368	144
(mean) outpatientHospExp	0.642	(0.338)	0.065	1.516	144
(mean) officeDoctorExp	1.415	(0.747)	0.348	3.072	144
(mean) Soutofpocket	1.209	(0.65)	0.307	2.858	144
(mean) SMedicare	2.123	(3.047)	0	10.76	144
(mean) SMedicaid	0.668	(0.285)	0.257	1.459	144
(mean) SPrivateIns	2.174	(1.084)	0.485	5.877	144
(mean) SVetIns	0.189	(0.202)	0.001	1.131	144
(mean) SChampus	0.006	(0.018)	0	0.115	144
(mean) STricare	0.043	(0.061)	0	0.28	144
(mean) SGovFed	0.028	(0.033)	0	0.2	144
(mean) SGovState	0.054	(0.061)	0	0.344	144
(mean) SWorkerComp	0.093	(0.077)	0	0.659	144
(mean) Sother	0.056	(0.036)	0.006	0.212	144
(mean) pcs	46.481	(5.17)	34.262	53.437	96
(mean) mcs	49.616	(0.931)	46.288	51.501	96

Table 3: Frequencies per cohort and year: MEPS 1996 to 2007

	Year											
Cohort	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	670	970	616	585	589	794	823	606	554	535	901	726
2	714	1,009	704	764	731	924	997	877	855	767	751	616
3	801	1,190	762	783	810	1,019	1,117	970	950	861	889	763
4	872	1,286	896	906	873	1,217	1,373	1,106	1,043	1,060	1,090	952
5	1,124	1,664	1,115	1,155	1,158	1,515	1,674	1,359	1,335	1,304	1,349	1,220
6	1,422	2,118	1,510	1,533	1,494	2,009	2,276	1,832	1,836	1,810	1,813	1,624
7	1,570	2,312	1,563	1,679	1,718	2,254	2,464	2,036	2,071	2,085	2,106	1,924
8	1,755	2,594	1,785	1,843	1,793	2,469	2,853	2,393	2,364	2,257	2,334	2,104
9	1,753	2,527	1,690	1,906	1,955	2,464	2,801	2,393	2,367	2,342	2,327	2,071
10	1,529	2,246	1,586	1,657	1,645	2,259	2,689	2,313	2,304	2,221	2,205	2,011
11	1,446	2,169	1,480	1,544	1,598	2,140	2,544	2,270	2,311	2,263	2,199	1,969
12	270	394	305	326	298	409	497	464	445	413	422	374
Sum	13,926	20,479	14,012	14,681	14,662	19,473	22,108	18,619	18,435	17,918	18,386	16,354

Figure 1: Cross section of health status: MEPS 1996-2007

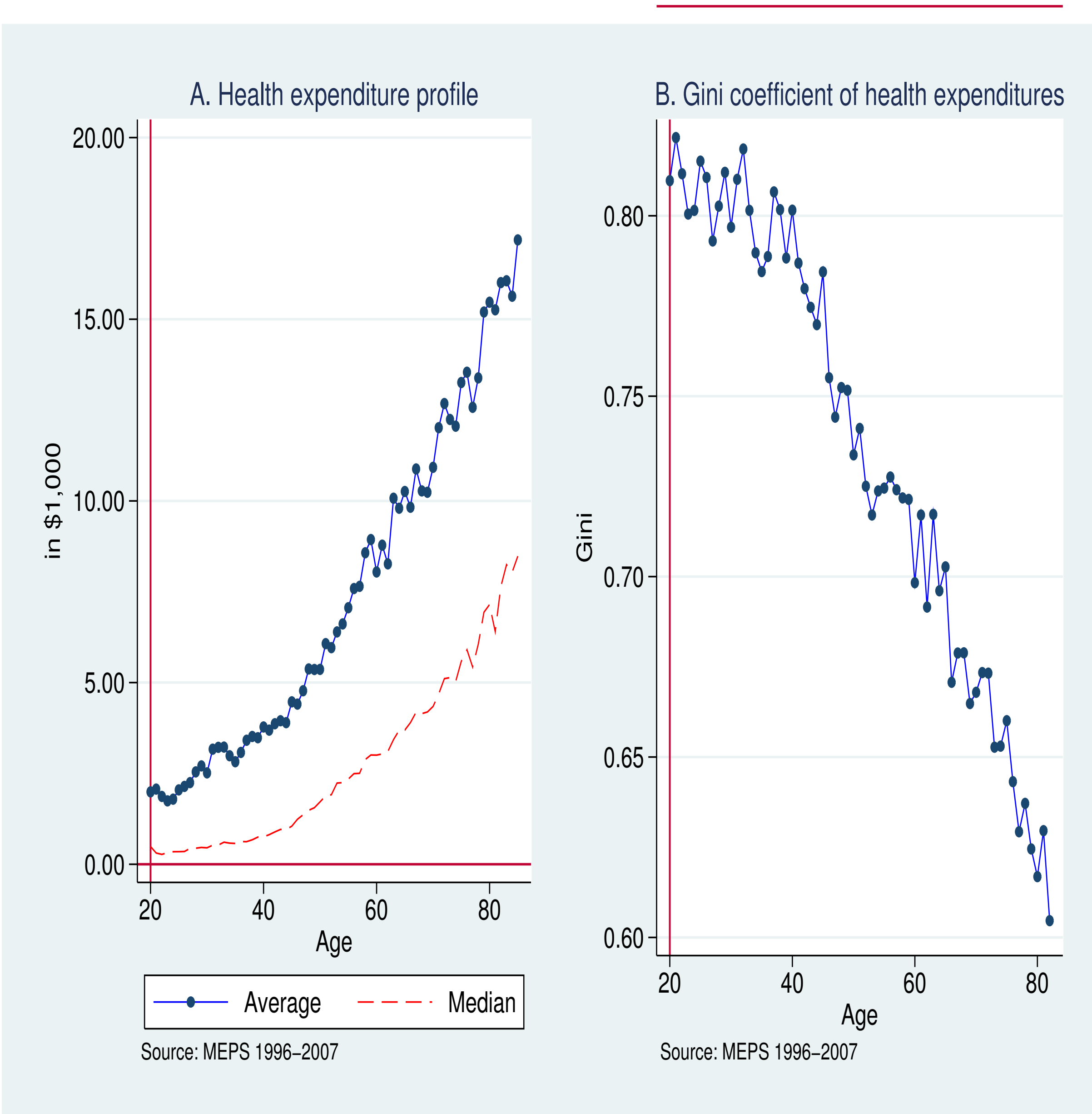

Figure 2: Cross section of health expenditures over age: MEPS 1996-2007

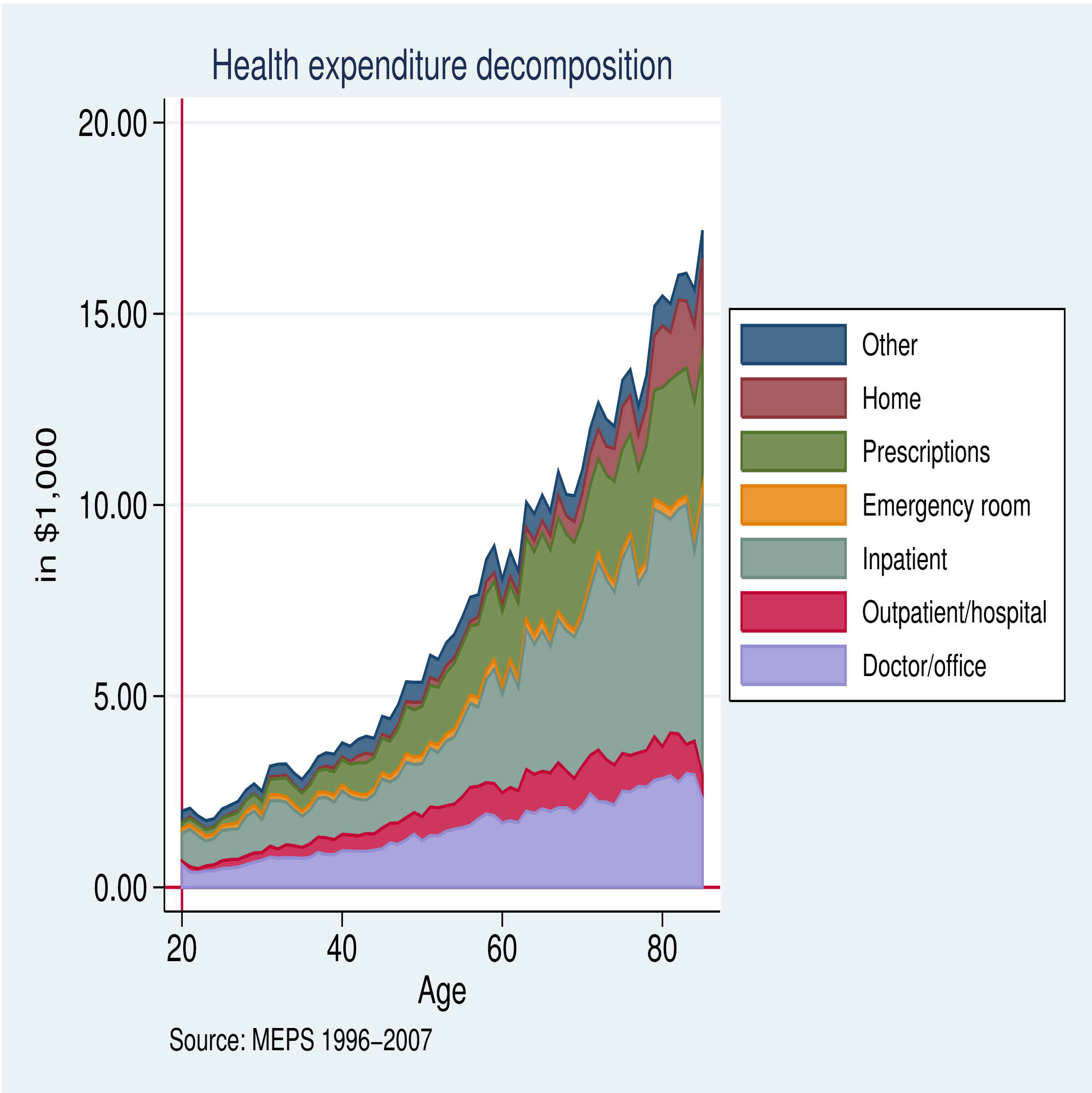

Figure 3: Cross section of decomposition of health expenditure over age: MEPS 1996-2007

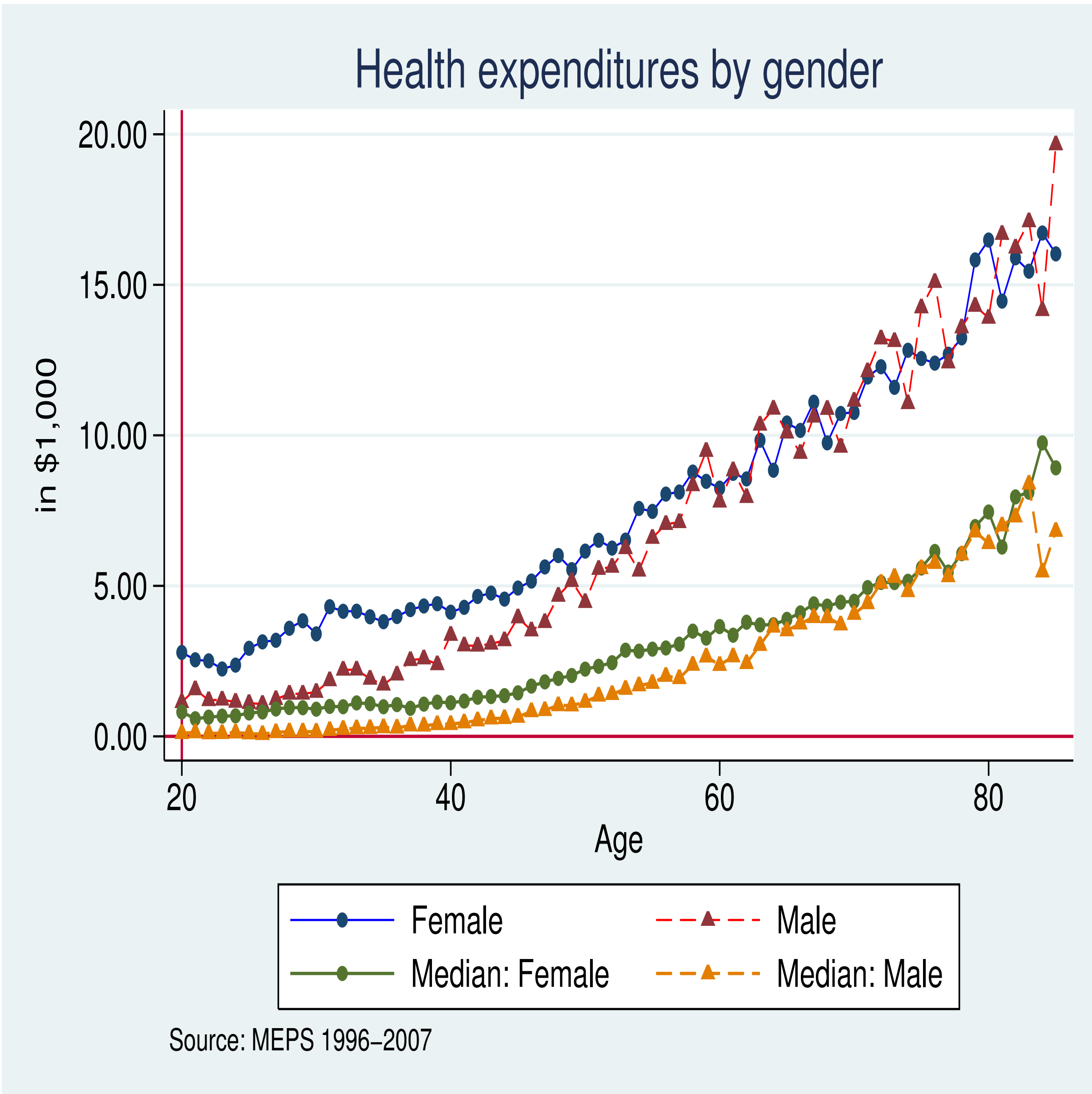

Figure 4: Cross section of health expenditures by gender: MEPS 1996-2007

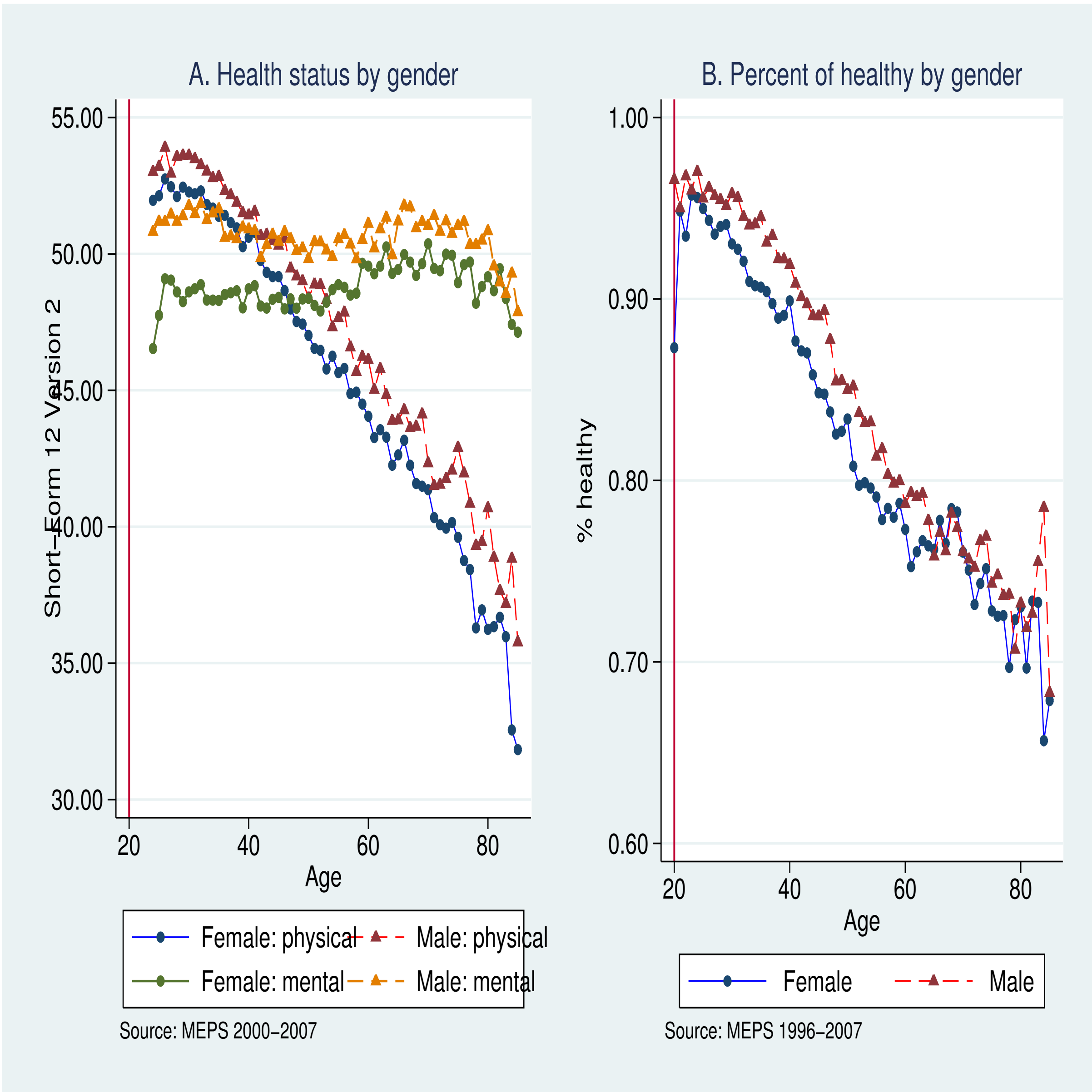

Figure 5: Cross section of health status by gender: MEPS 1996-2007

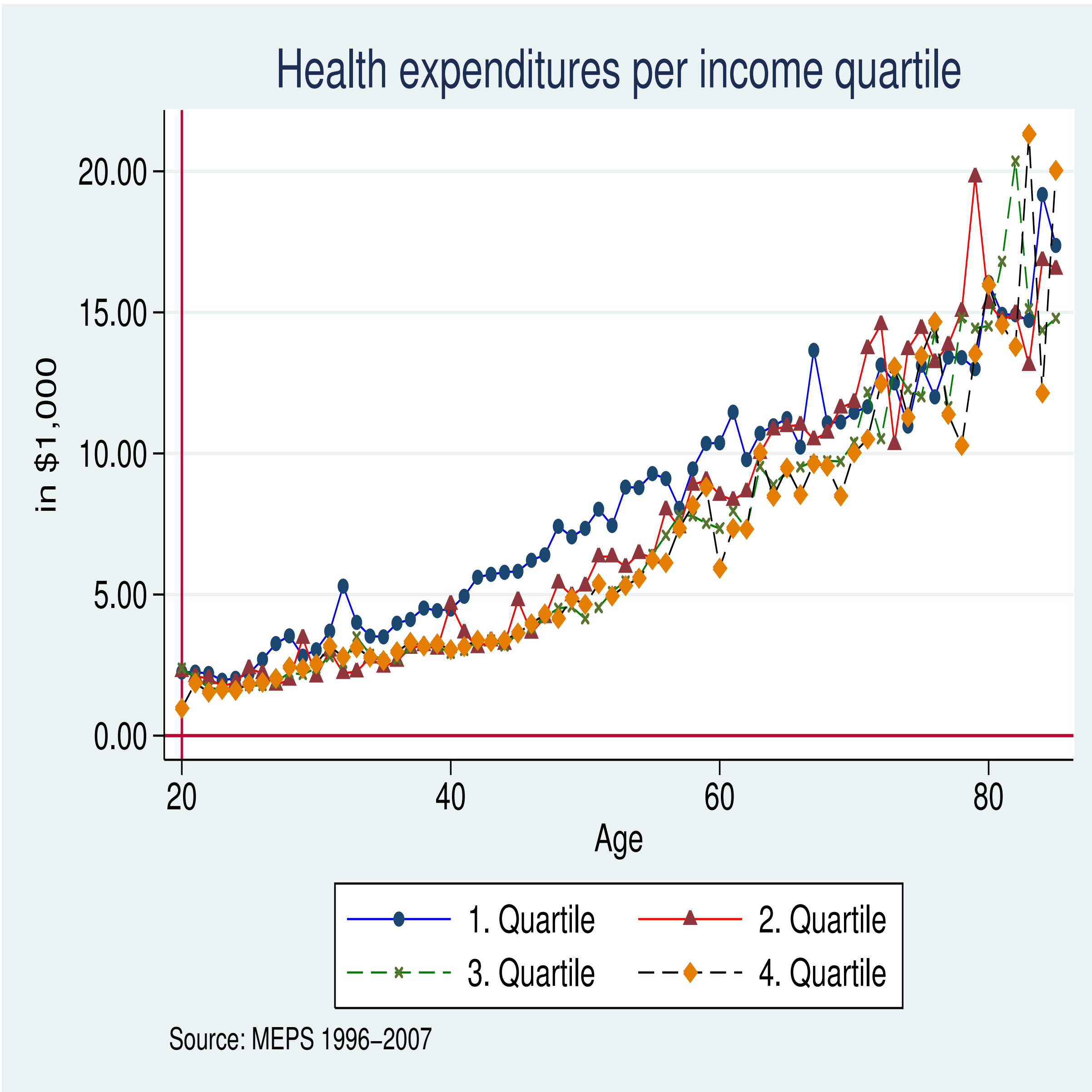

Figure 6: Cross section of health expenditures by income quantile: MEPS 1996-2007

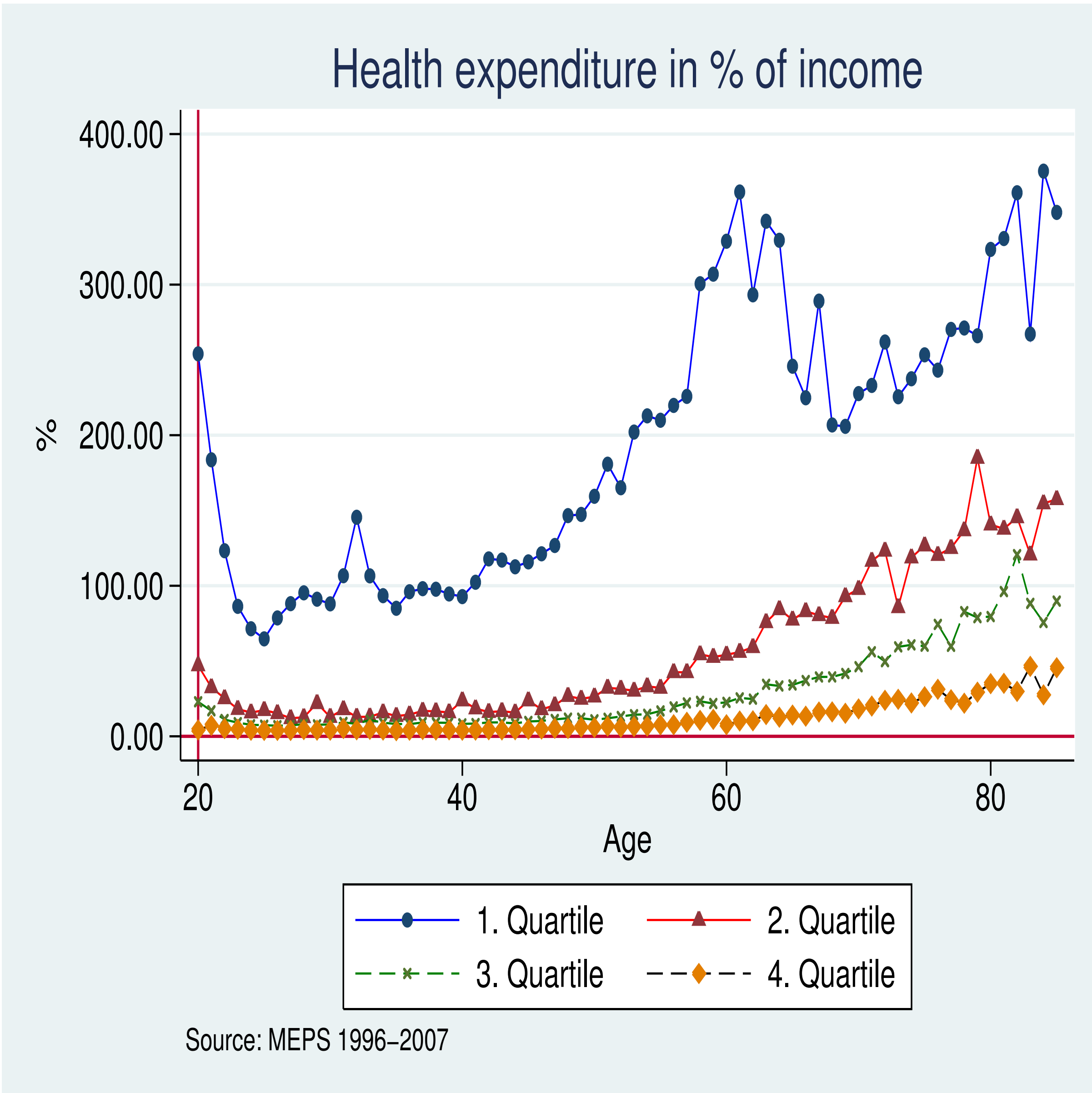

Figure 7: Cross section of fraction of health expenditures by income quantile: MEPS 1996-2007

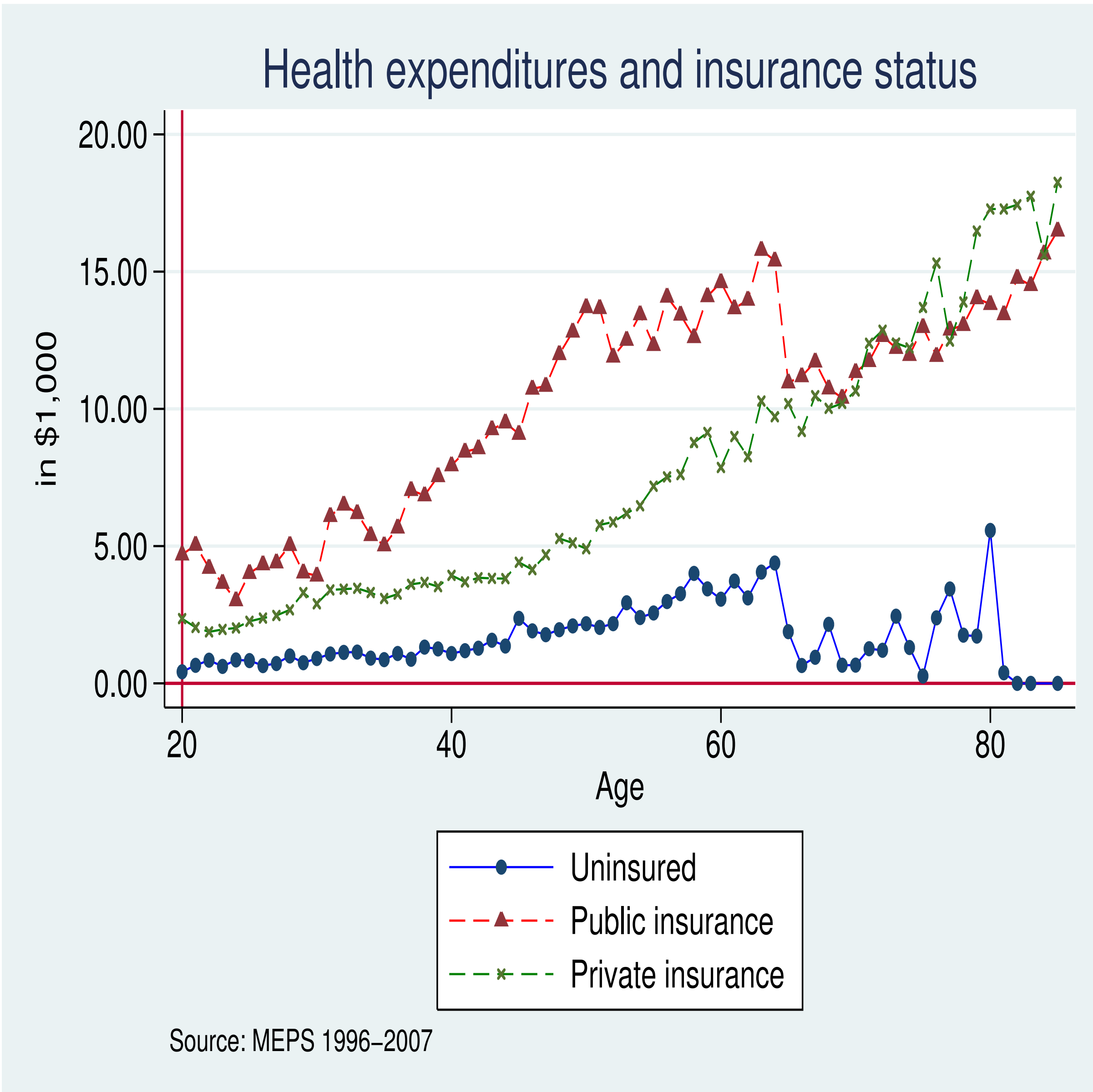

Figure 8: Cross section of health expenditures by insurance state: MEPS 1996-2007

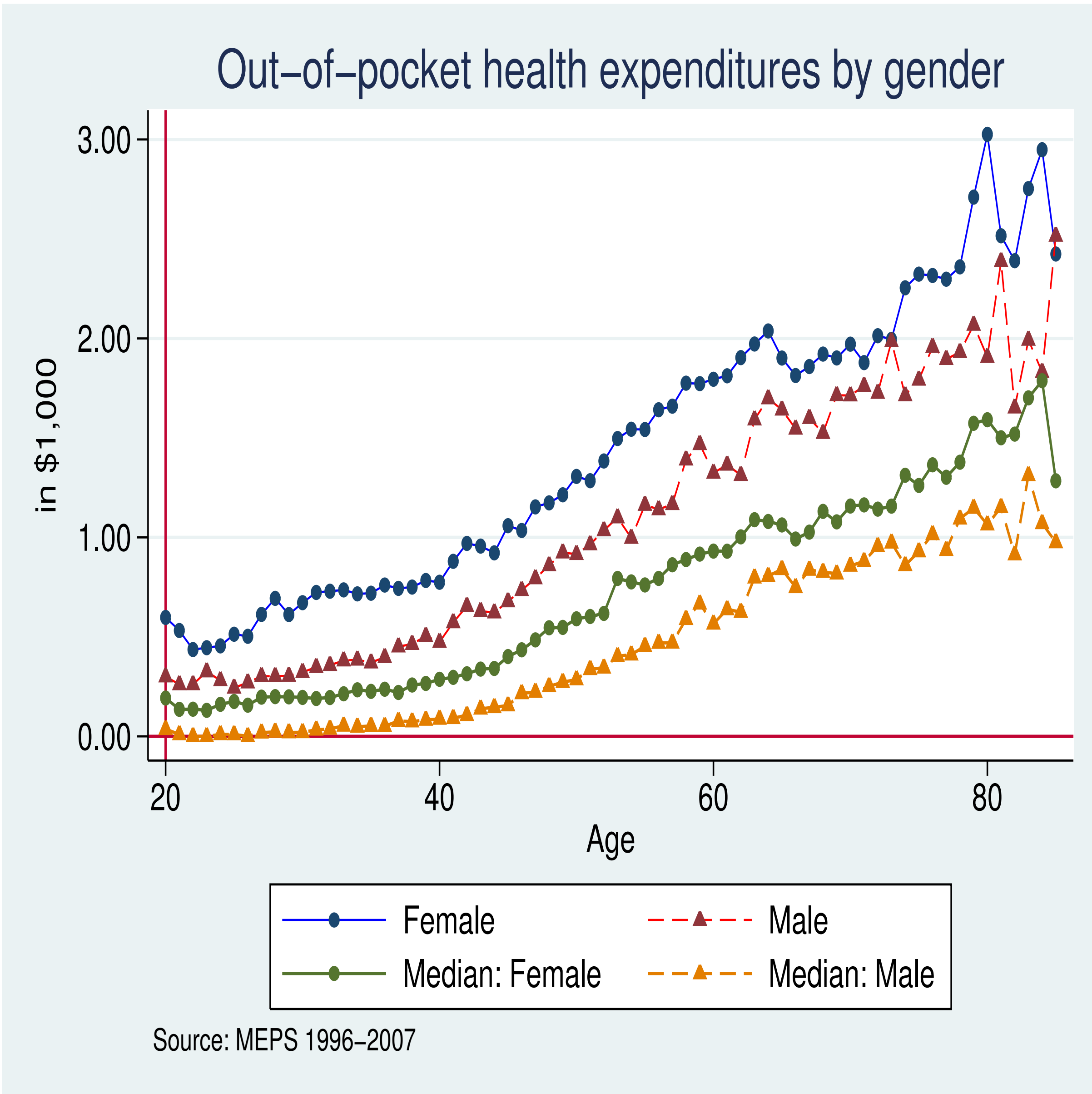

Figure 9: Cross section of out-of-pocket health expenditures by gender: MEPS 1996-2007

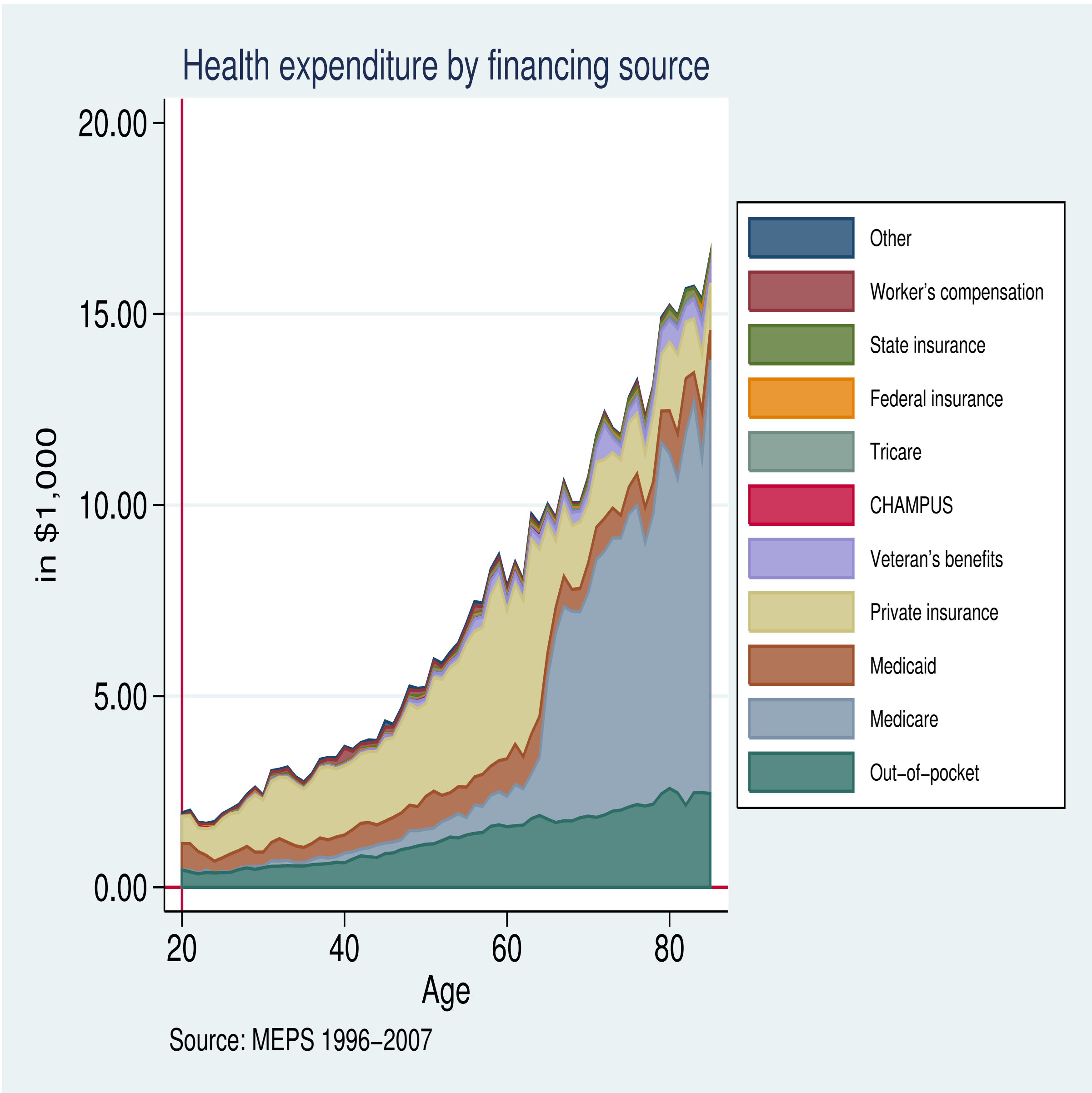

Figure 10: Cross section of health expenditures by financing source: MEPS 1996-2007

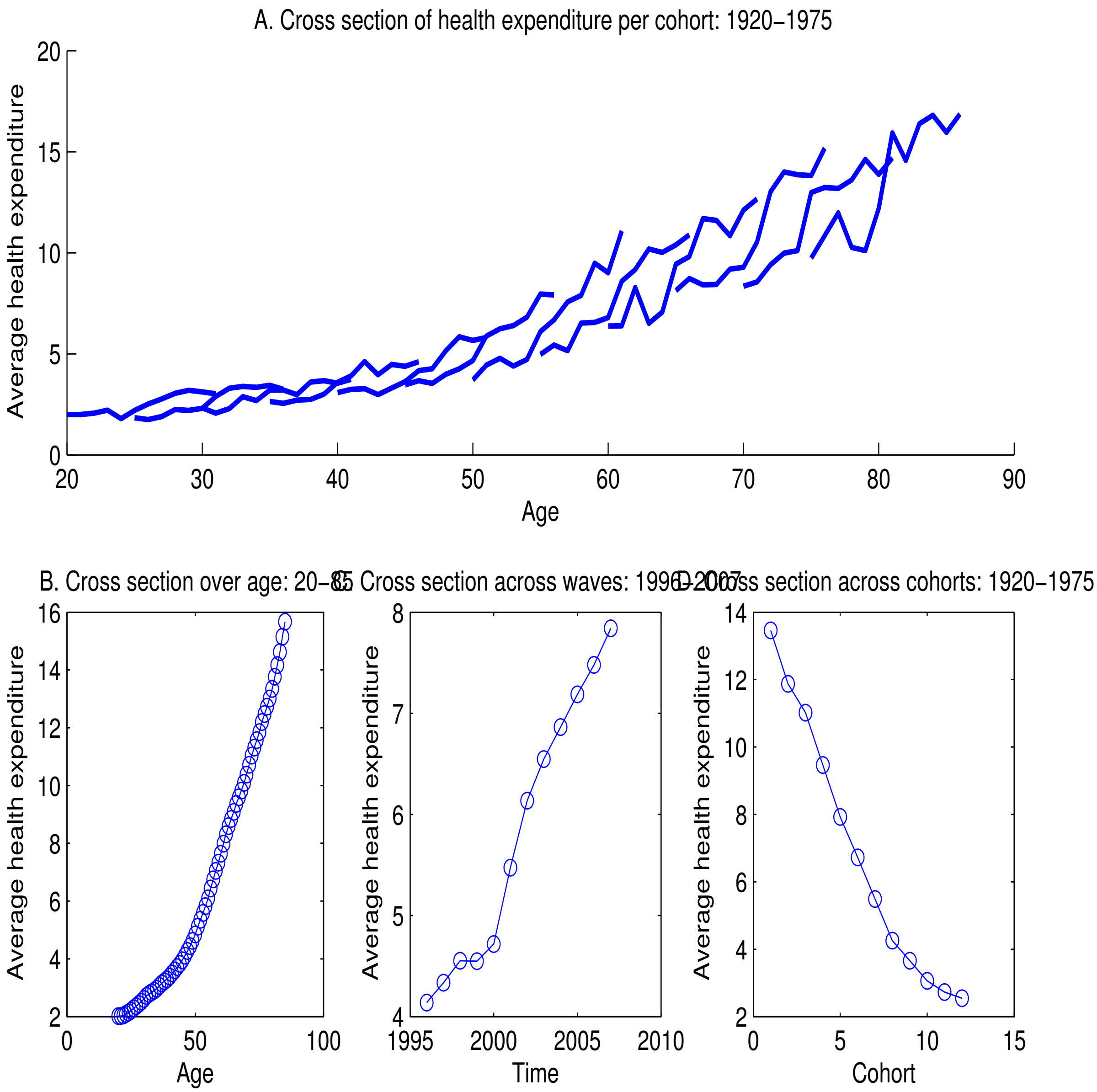

Figure 11: Cross section of health expenditure using the pseudo panel from MEPS: 1996-2007

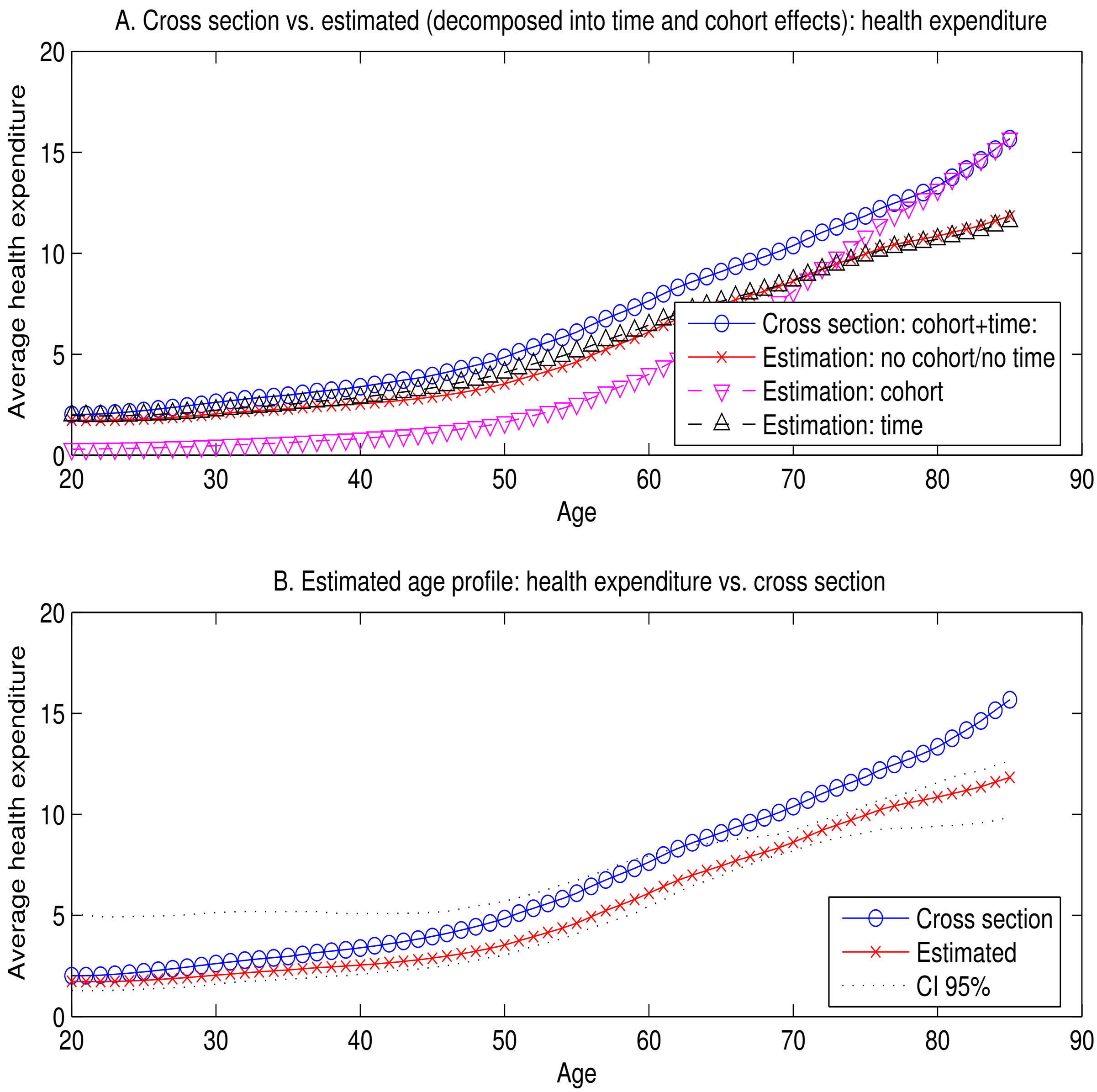

Figure 12: Health expenditure profile controlling for time and cohort effects, including bootstrap confidence intervals: MEPS 1996-2007