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## **Health accidents and wealth decline in old age**

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**JEL Codes:**

**Keywords:** Life cycle model, saving behavior, health shock, difference-in-differences



# Health accidents and wealth decline in old age

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## Abstract

This paper explores the impact of a health shock and changes in survival probability on the savings and portfolio choices of older individuals. Using a theoretical framework featuring a portfolio choice that incorporates imperfect annuity markets, we analyze how elderly individuals, whose survival probability has been altered by a health shock, allocate their resources. A difference-in-differences approach complements the theoretical approach by taking into account the effect of age and cohort, and controlling for selection bias related to health events at older ages. Our analysis utilizes a panel of 5570 observations from the Survey of Health, Aging, and Retirement in Europe (SHARE, 2011 and 2017). Both theoretical and empirical findings converge, indicating that experiencing a health accident such as a stroke or heart attack leads to a decrease in safe savings. Consequently, investing in annuities becomes crucial in enabling individuals to mitigate the consequences of poor health in aging economies.

**Key words:** Life cycle model, saving behavior, health shock, difference-in-differences

## 1 Introduction

Population aging is putting great pressure on public pay-as-you-go pension, health-care, and long term health-care systems. Since demographics also impacts savings, the implications of aging are high. Long-term savings and venture capital are crucial for raising the economic growth and promoting development. The question is therefore whether the generations in the second half of their lives will liquidate their assets, as predicted by the first version of the life cycle theory, or whether they will keep them for various reasons, whether to insure themselves against the risk

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of longevity, the health risk, which we know will inevitably increase, or, for example, for bequest reasons. The choices the older population make will have an impact on the financing of the productive economy. If a large proportion of senior citizens with high savings turn away from equities or bonds, then some of the risky investments can no longer be made, with all the consequences that this may have on innovation and growth. And beyond the impact of population aging on savings and portfolio choices, as people live longer, they will face more health risks and higher health care expenditures.

The pioneering reference for the analysis of savings behavior is the life-cycle theory (Ando and Modigliani 1963, Modigliani and Brumberg 1954). This stream of literature focuses on life-cycle optimal allocation issues. After incurring debts during their youth, economic agents save, allowing them to repay their debts at the beginning of their lives, and then to accumulate resources to finance, in particular, consumption during retirement. This optimization over the life cycle and the simplifying assumption of perfect certainty imply that individuals anticipate the date of their death, and then their survival probability at each age in order to liquidate their wealth. In the life cycle model, health shocks can impact portfolio choice through different channels: preferences by affecting marginal utility of consumption (Edwards 2006, 2007, 2008), background risks due to unexpected out of pocket medical costs (Kimball and Elmendorf 2000, Viceira 2001, Dobkin et al. 2018, Jones et al. 2020), and expectations about life expectancy (Bodie and al. 1992). As early as 1965, Yaari started a long tradition of life cycle models. In his pioneering article, he concluded that certain economic agents should annuitise all of their savings. This widely cited result were based on several strong assumptions, including in particular the market completeness and of course the absence of uncertainty except the time of death. These assumptions, such as the van Neumann-Morgenstern expected utility, intertemporally separable, the absence of bequest motive, or the fact that the annuities available for purchase were actuarially fair, were extremely restrictive. An extensive literature has considered the implications of relaxing these different assumptions.

In recent decades, theoretical life cycle analysis have been extended into the empirical literature. The analysis of the impact of health risks on savings at older ages has required authors to use longitudinal data in order to take into account the effects of age but also of the generation of membership. Moreover, studying the impact of a health shock on savings requires controlling for selection bias in the occurrence of the event. Although individuals may not be aware of it, their unobservable, or sometimes observable but unaware, characteristics may affect their accumulation trajectories differently from those of the general population. Focusing on people aged 70 and over with the Health and Retirement Study (HRS) and the Asset and Health Dynamics Among the Oldest Old (AHEAD), Lee and Kim (2008) show in the early 2000s that a health accident tends to reduce the wealth of the elderly in the short term, but that the effect gradually fades. However, the health event leads to a greater wealth depletion when it occurs in later life. The overall impact of health increases with age. A decade later, Wallace et al. (2017) used also data from the Health and Retirement Study, and show that a temporary decrease in the health status implies an immediate loss of wealth between 3 and 6%, before a mitigation of the impact. But a permanent deterioration of health after a health accident leads to a reduction between 12 and 20% in the wealth of individuals over 10 years. Numerous studies conducted with this same database (Health and Retirement Study) arrive at the same conclusion: the occurrence of a transitory health accident, or the onset of a long-term illness, is source of wealth depletion (Wu

2003, Smith 2004, Lee and Kim 2008, Coile and Milligan 2009, Cooke et al. 2016, Poterba and Venti 2017). Using a sample of over 65 individuals from the HRS, Poterba and Venti focus on short term impact of 8 health events. They conclude that stroke conduct to a significant decline of the net worth in the 2 years following the diagnosis: the average decline is 25,000 US dollars, going from 4,682 dollars for low wealth individuals, to 59,282 dollars for wealthier individuals. More recently, Bonekamp and Wouterse (2022) explored the Dutch case, thus extending the spectrum of research on this topic, which was essentially focused on the American case. They concluded that there is no impact of hospitalisations on savings at older ages in the Netherlands. The authors explain that in the presence of more generous social security coverage than in the United States, Dutch consumers do not seem to be subject to the theoretical mechanisms of life-cycle hypothesis, at least in the short run, or only very weakly. In Europe, the need to save for health care costs is indeed less urgent, partly because the rate of users facing catastrophic health care costs is lower than in the United States. In the United States, health accidents can not only lead to loss of income, but also to very significant increases in out-of-pocket health care costs for patients (Dobkin et al. 2018, Jones et al. 2020). Catastrophic health care spending is defined by the OECD as spending more than 40 percent of remaining income after spending on basic needs. The rate of users facing this type of expenditure reaches 7.4% in the United States, while it is below 2% for example in Slovenia, Czech Republic, Ireland, United Kingdom, Sweden and France (OECD 2019). But it is around 10% or above in Greece, or Hungary.

To our knowledge, there has been no conclusive evidence in the existing literature to theoretically establish and empirically assess the impact of a health shock at high ages on individuals' savings and asset allocation choices. We therefore answer the following research question : how does a health shock and the modification of the survival probability impact savings and portfolio's choices at old age?

We contribute to the literature by articulating the life cycle theoretical approach to empirical analyses on a European case which is known not to respond to the same realities as the American market. The contribution of this paper is threefold :

- we provide a theoretical framework featuring a portfolio choice within imperfect annuity markets, which allows to provide an analysis on the allocation choices of elderly individuals whose survival probability is modified,
  - we extend the theoretical approach with an empirical analysis, taking into account the effect of age and cohort, and controlling for selection bias in the occurrence of health events at older ages,
  - finally, we study the French case and complement the very limited literature on the European market.

Our life-cycle model with uncertain lifetime permits to theoretically assess the impact of an exogenous change in the probability of survival, particularly in the case of a health shock, on the saving behavior and the composition of the agent' portfolio. We assume imperfect annuity markets and risky assets. We show that, provided that the absolute aversion to risk does not change much with the realization of the risk, a reduction in the survival probability (induced by e.g. a heart attack or a stroke) causes a decrease in the non-risky wealth while leaving the risky wealth unchanged.

Based on the theoretical model considering especially risky assets, we use two non-consecutive waves of the Survey of Health and Retirement in Europe (2011, 2017) to examine how the structure of household savings evolves with age and after a health event. We build on both theoretical and empirical literature by adopting a cohort approach and by analyzing a division of financial wealth between risky (shares, bonds, mutual funds) and safe assets (individual retirement accounts, contractual savings, endowment insurance and cash in bank accounts). A difference-in-differences model allows to assess the impact of a stroke or heart attack on wealth depletion, both in comparison to individuals whose probability of survival is not affected by a health event, but also in comparison to their situation before the event. In 2015, 17.7 million deaths were attributable to cardiovascular disease, accounting for 31% of total mortality. The risk of cardiovascular disease increases with age: men in particular become more at risk from the age of 55, while among women, the risk of cardiovascular disease becomes more serious from the age of 65. In France, these pathologies are the second highest source of mortality, and even the first one for women of all ages. We focus in our empirical approach on stroke and heart attacks as they are the most sudden and well-known manifestations cardiovascular diseases. This health shock is assumed to negatively impact the survival probability throughout the world as shown by medical researches (Boysen et al. 2009, Shavelle et al. 2019). In the present research, being at risk of stroke or heart attack from 2011 and having experiencing this health event between 2011 and 2017 materializes a shock on survival probability. The probability of survival after shock is affected by health shock (stroke, heart attack) but also by pre-existing physiological factors (Dupre and Nelson, 2016; Go et al., 2014; National Center for Health Statistics (US), 2014). The methodology allows controlling for the selection bias in the health event and the effective onset of the accident, thus making them comparable. Difference-in-differences allows indeed controlling observed heterogeneity between individual through the introduction of control variables, but also unobserved heterogeneity between individual with and without health events such as stroke or heart attacks. Panel data have the advantage of preventing the cohort effect from being neglected. The DiD approach allows comparing two types of individuals after a health shock, both types being distinguished only by different survival probability, one of them being lower than the other.

The remainder of the paper proceeds as follows. We develop the theoretical model in the second section. The third section is devoted to the empirical strategy and its results. We discuss our results and conclude in the fourth section.

## 2 Theoretical approach

We consider a life-cycle model with uncertain lifetime. The aim is to study the impact of an exogenous change in the survival probability, which typically occurs following a stroke or a heart attack, on the saving behavior and the composition of the agent's portfolio. Our model builds on a long tradition initiated by Yaari (1965) that we extend by considering a choice between safe and risky assets.

The agent lives for at most two periods of life, and the survival rate between period 1 and 2 is denoted  $p \in (0,1)$ . With probability  $(1 - p)$ , the agent lives for one period and consumes a quantity  $c_1$ . With probability  $p$ , the agent lives for two periods and consumes quantities

$(c_1, c_2)$ . As of period 1, the life-cycle utility function is given by:

$$u(c_1) + pEu(\tilde{c}_2), \quad (1)$$

where  $E$  is the expectation operator,  $u(\cdot)$  is the utility function, which is increasing, concave and satisfies  $\lim_{x \rightarrow 0} u'(x) = +\infty$ , and where  $\tilde{c}_2$  denotes the second period consumption understood as a random variable. During the first period of life, the agent shares an exogenous income, denoted  $w > 0$ , between consumption and savings. We denote by  $a$  and  $b$  the investments made in safe assets and risky assets, respectively. The budget constraint during this period is thus:

$$c_1 = w - a - b. \quad (2)$$

Let  $R > 0$  denotes the return on the safe asset and  $\tilde{R}$  denotes the one on the risky asset, as a random variable with support on  $(0, +\infty)$ . No assumption on the expected return of the risky asset is needed, but some realizations of  $\tilde{R}$  should be lower than  $R$  in order to have an interesting problem with an interior solution. Since there are no bequest motives, all wealth is annuitized and the annuity premium is  $1/\pi$ , with  $\pi \in [p, 1]$ . The annuity market is said to be perfect when  $\pi = p$  and imperfect when  $\pi > p$ . Thus, the remunerations of the safe and risky assets are  $R/\pi$  and  $\tilde{R}/\pi$ , respectively, and the second period consumption solves:

$$c_2 = \frac{R}{\pi}a + \frac{\tilde{R}}{\pi}b. \quad (3)$$

By replacing the constraints (2) and (3) into the utility function (1), the problem of the agent is expressed as follows:

$$\max_{\{a, b\}} u(w - a - b) + pEu\left(\frac{R}{\pi}a + \frac{\tilde{R}}{\pi}b\right). \quad (4)$$

The first order conditions with respect to  $a$  and  $b$  are:

$$-u'(w - a - b) + pREu'\left(\frac{R}{\pi}a + \frac{\tilde{R}}{\pi}b\right) = 0, \quad (5)$$

$$-u'(w - a - b) + pE\tilde{R}u'\left(\frac{R}{\pi}a + \frac{\tilde{R}}{\pi}b\right) = 0, \quad (6)$$

respectively.

The study of the problem is made much easier by considering two changes in variables. The first one introduces total savings  $s$ , such that  $s = a + b$ , while the second one proposes an additive decomposition of the stochastic return in order to relate it to the safe return:

$$\tilde{R} = R + \tilde{\varepsilon}$$

where the support of random variable  $\tilde{\varepsilon}$  is  $(-R, +\infty)$ .

The first order conditions can thus be rewritten as:

$$-u'(w - s) + \frac{p}{\pi} REu' \left( \frac{R}{\pi} s + \frac{\tilde{\varepsilon}}{\pi} b \right) = 0, \quad (7)$$

$$E\tilde{\varepsilon}u' \left( \frac{R}{\pi} s + \frac{\tilde{\varepsilon}}{\pi} b \right) = 0. \quad (8)$$

Let us first consider the case of an imperfect annuity market, where the annuity premium is lower than the fair price, i.e. for  $\pi > p$ . The case of an imperfect annuity market is the most realistic and can be justified by asymmetric information (Finkelstein and Poterba, 2004). This implies that the pricing of the annuity is not modified after a health shock, which is also what we observe on the market.

Condition (8) characterizes a trade-off between the risky and the safe assets. Supposing that  $u$  is an exponential function, say  $u(x) = -\exp(-\lambda x)$  with  $\lambda > 0$  being the absolute aversion to risk, the evaluation of this arbitrage gives :

$$E\tilde{\varepsilon}\exp\left(-\lambda\frac{\tilde{\varepsilon}}{\pi}b\right) = 0. \quad (9)$$

In that case, the optimal investment in the risky asset is uniquely defined by (9) and does not depend on the survival probability. A change in  $p$  is going to impact the total wealth  $s$ , through equation (7), and thus the investment in the safe asset  $a$ , leaving  $b$  unchanged.

Exponential utility functions have been extensively used in the literature since the seminal works of Merton (1969, 1971). They imply that the risky investment does not depend on the level of wealth. For a general utility function, one may use condition (8) as an implicit function to define the relation between  $s$  and  $b$ . Using the Implicit Function Theorem, we obtain :

$$\frac{db}{ds} = -\frac{RE\tilde{\varepsilon}u'(\tilde{c}_2)\frac{u''(\tilde{c}_2)}{u'(\tilde{c}_2)}}{E(\tilde{\varepsilon})^2u''(\tilde{c}_2)}, \quad (10)$$

whose sign is the one of the numerator.

Using (8), we see that  $db/ds = 0$ , if the absolute aversion to risk is constant and that  $db/ds > 0$  if it is an decreasing function, which is the case for usual functions with constant relative risk aversion like the log function or the power function. In that case, the sign of the impact of  $p$  on  $b$  is the same as the one of  $p$  on  $s$ , which is obtain by using (7) as an implicit function such that:

$$\frac{ds}{dp} = -\frac{\frac{1}{\pi}REu'(\tilde{c}_2)}{u''(w-s) + p\left(\frac{R}{\pi}\right)^2 Eu''(\tilde{c}_2) - \frac{p}{\pi^2} \frac{(RE\tilde{\varepsilon}u''(\tilde{c}_2))^2}{E(\tilde{\varepsilon})^2u''(\tilde{c}_2)}}. \quad (11)$$

The existence of a unique solution to the optimization problem implies that the denominator of (11) is negative, which allows to conclude that  $ds/dp > 0$ .

An increase in  $p$  is indeed understood as a larger weight associated to the second period utility. Longer life implies more savings and a health accident to the survival probability implies a



decrease in savings. Following a change in  $p$ , the portfolio composition is also modified according to the shape of the utility function. In particular, we conclude that the investment in the risky asset is left unchanged if the absolute aversion to risk barely change with the realization of the random variable. In that case, the decrease in longevity only translate into a decrease in the investment in the safe asset.

Conversely, if the absolute aversion to risk increases with the returns, the investment in the risky asset would increase with longevity.

Note that this result strongly depends on the assumption of an imperfect annuity market. For  $\pi = p$ , the condition (8) rewrites as:

$$E\tilde{u}'\left(\frac{R}{\pi}s + \frac{\tilde{\varepsilon}}{\pi}b\right) = 0, \quad (12)$$

and even with a constant absolute aversion to risk, the investment in  $b$  is modified by  $p$ .

### 3 Empirical strategy

In this empirical part, comparing the impact on different survival probability on decumulation behavior among elder individuals leads us to compare a sample victim of a stroke or a heart attack and a sample that did not experience such a health shock.

#### 3.1 The data

The Survey of Health, Ageing and Retirement in Europe (SHARE) provides information particularly on Europeans belonging to households where at least one member has reached the age of 50. It is a valuable source of information on the senior population in a context of demographic aging more or less marked according to European countries. It has been carried out at regular intervals since 2004 and thus makes it possible to follow individuals over several years. Today, the survey is conducted in 27 countries, including France. The multiple modules provide information on the socio-demographic attributes of the household, but also on the standard of living, the situation on the labor market for people still in work, savings and wealth, mental and physical health, cognitive abilities, access to health care, etc. The use of these data is only possible for scientific purposes, and European users undertake to respect the laws of their countries concerning the protection of personal data. In France, data protection is governed by the General Data Protection Regulation. Furthermore, SHARE survey data are fully anonymized (as defined by the strict norms of the German Federal Statistics Act and the German Federal Data Protection Law). The use of SHARE data therefore requires no additional ethical approval.

We choose to track individuals present in wave 4 and wave 7<sup>4</sup>, and thus build a panel with data from 2011 and 2017. We target these waves because they not only allow to select individuals over a period of time that is reasonably far from the 2008 crisis, but we also opt for a time lag of 6 years, which seems to be interesting in order to capture not only the short-term effects of the health shock. Moreover, having panel data is very instructive in this case, as it makes it possible to identify a category of the population that is the victim of a health shock before it has even occurred.

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<sup>4</sup> 10.6103/SHARE.w4.800 and 10.6103/SHARE.w7.800 (Börsch-Supan et al., 2013 and Bergmann and al., 2019).

Financial data are particularly accurate and well documented in the SHARE survey. They allow us to distinguish financial wealth from real estate and land assets, for example, or from physical assets such as cars. We are particularly interested in financial assets, which we distinguish according to whether they are risky or not. Safe financial assets include amounts held in bank accounts, fully or partially liquid savings accounts, long-term savings such as endowment insurance. The asset class we call risky includes stocks, bonds, and investment funds. We describe more precisely the wealth of the individuals of the sample in the following section.

### **3.2 Descriptive statistics**

The SHARE survey data clearly show the decumulation trend among individuals belonging to a household with at least one member who has reached the age of 50. In 2011, our sample is composed of 2585 individuals aged 37 to 92, with an average age of 64.24. Among these individuals, present also in 2017, 259, or about 10%, have a health event between the two dates. We target individuals, but for each individual, we also use information on its households. For example, we compute the average per capita wealth within the households, thus making the implicit assumption that wealth is equally distributed among couples.

The average financial wealth of individuals is 54,591 euros in 2011, while it is only 16,466 euros in 2017. Table 1 provides details of financial asset holdings according to whether individuals experience a health accident between 2011 and 2017, and by year (2011 and 2017). The downward trend in financial savings is equally true for those with and without a health accident. In addition, the amounts of financial assets are lower among those who have a heart attack or stroke than those who do not. This is true both after the event and before the occurrence of the health shock. In 2011 non-risky assets amount to 51,249 euros for those who do not experience a health shock, while they amount to 28,874 euros for those who will experience a health shock between 2011 and 2017. These amounts decrease to 14,441 euros and 10,952 euros respectively in 2017.

Let see now the profile of heart attack/stroke victims, compared to the one who do not experience such a health accident. The World Health Organization reports that stroke is the leading cause of death worldwide. In 2015, 17.7 million deaths were attributable to cardiovascular disease, accounting for 31% of total mortality. The risk of cardiovascular disease increases with age: men in particular become more at risk from the age of 55, while among women, the risk of cardiovascular disease becomes more serious from the age of 65. In France, these pathologies are the second highest source of mortality. Stroke and heart attacks are the most sudden and well-known manifestations. The average age of stroke victims is 74 years old, and the average age of male heart attacks victims is 61 years old, while it is 75 years old for women. The occurrence of these types of events creates a life expectancy shock for the people who suffer from them. Although the probability of survival for stroke and cardiac victims has improved in recent decades, it remains lower than for those who have not experienced this type of health event. This is particularly true for those older than 65 years old at the time of the health event (Boysen et al. 2009, Shavelle et al. 2019). The World Health Organization reports that in order to cope with this deterioration of health, older people change their value-for-money behaviors (WHO 2015).

In our sample, heart attack/stroke victims are in average slightly older (67.98 in 2011 vs

64.24), have a one year studies shorter (10.83 years vs 11.84), are more frequently retired (69% against 56% in 2011) than others. These differences seem to argue that the chosen health event, although unpredictable in nature, occurs more particularly among certain profiles. In the next step, we will therefore control for observed and unobserved heterogeneity that could bias the measurement of the impact of the health accident.

Table 1: Descriptive statistics

|   | No health accident n=2526 |           |     |           | Health accident n=259     |           |     |           |
|---|---------------------------|-----------|-----|-----------|---------------------------|-----------|-----|-----------|
|   | Mean value<br>/proportion | S.D       | Min | Max       | Mean value<br>/proportion | S.D       | Min | Max       |
|   | Year 2011                 |           |     |           |                           |           |     |           |
| Safe assets<br>(euros)                                    | 51,249.43                 | 157,345.1 | 0   | 3,615,327 | 28,874.16                 | 62,170.09 | 0   | 704,842.6 |
| Risky assets<br>(euros)                                   | 5,414.1                   | 21,349.93 | 0   | 375,000   | 5,504.17                  | 23,429.92 | 0   | 299,100.8 |
| Age   | 64.24                     | 9.86      | 37  | 92        | 67.98                     | 10.19     | 42  | 91        |
| Number of<br>years of<br>education<br>from 6 years<br>old | 11.84                     | 3.73      | 0   | 25        | 10.83                     | 3.4       | 0   | 23        |
| With Partner  | 0.69                      | -         | 0   | 1         | 0.61                      | -         | 0   | 1         |
| Women   | 0.59                      | -         | 0   | 1         | 0.57                      | -         | 0   | 1         |
| Retired   | 0.56                      | -         | 0   | 1         | 0.69                      | -         | 0   | 1         |
|   | Year 2017                 |           |     |           |                           |           |     |           |
| Safe assets<br>(euros)                                    | 14,441.1                  | 48,352.47 | 0   | 1,122,209 | 10,952.18                 | 39,711.1  | 0   | 351,150.6 |
| Risky assets<br>(euros)                                   | 2,496.85                  | 17,466.16 | 0   | 550,000   | 913.02                    | 16,652.42 | 0   | 550,000   |
| Age   | 70.24                     | 9.86      | 43  | 98        | 73.98                     | 10.19     | 48  | 97        |
| Number of<br>years of<br>education<br>from 6 years        | 11.84                     | 3.73      | 0   | 25        | 10.83                     | 3.4       | 0   | 23        |

|              |      |   |   |   |      |   |   |   |
|--------------|------|---|---|---|------|---|---|---|
| old          |      |   |   |   |      |   |   |   |
| With Partner | 0.64 | - | 0 | 1 | 0.56 | - | 0 | 1 |
| Women        | 0.59 | - | 0 | 1 | 0.57 | - | 0 | 1 |
| Retired      | 0.74 | - | 0 | 1 | 0.78 | - | 0 | 1 |

Source: 2785 individuals, from the Survey on Health, Aging and Retirement in Europe (SHARE), waves 4 & 7 for France. Reading grid: On average, individuals are 64,24 years old in 2011. 56% of the sample are retired in 2011. 259 individuals experienced a heart attack or a stroke.

### 3.3 The model

The empirical approach leads to directly assess the impact of the health accident on the safe and risky assets held, which slightly changes the perspective with which the issue is analyzed in the theoretical model. Indeed, the theoretical model allowed to determine the effect of the survival probability on risky and safe capital, knowing that the heart attack or the stroke were taken as exogenous negative shocks on the probability of survival. Assuming that the health accident is exogenous requires selecting the appropriate sample and method. Thus, for comparable individuals, the occurrence of the health event can be considered random. We propose a difference-in-differences (DiD) model (Angrist and Pischke 2009, Blundell and Costa Dias 2009, Imbens and Wooldridge 2009, Lechner 2010) to assess the impact of a health accident on individuals' assets. By using individual data before and after the occurrence of the health event, we can analyse the differences in savings trajectories between affected and unaffected individuals, while controlling for observable and unobservable heterogeneity.

Individuals experiencing a health shock between the first wave of observation, 2011, and the second one, 2017, are classically referred to as *treated* individuals. Individuals not experiencing a cardiac event or stroke are the control group. DiD allows for time invariant heterogeneity. This allows in particular to account for unobserved differences between people who experience a health accident and those who do not, and consequently to control for selection operating on unobservable heterogeneity. This is especially relevant in the present case study because people may have health risk factors of which they are unaware, and which a fortiori, we cannot control through observed variables. The literature also reports that both health status and portfolio choice are affected by unobserved characteristics (Love and Smith, 2010). The survival probability, of which the theoretical model allowed to determine the impact, depends on the onset of the health accident, but also on the accident prone terrain (depending on the lifestyle, food hygiene, anxiety level, etc.), that is the unobservable heterogeneity.

Let  $Y_{it}^J$  denote the value of the assets held in risky or non-risky assets by individual  $i$ , in wave  $T$  with  $J = C, T$  indicating if the individual belongs to the treated or the control group. The average impact of the health accident on wealth held is given by  $\Delta$ :

$$\Delta = (Y_t^T - Y_{t-1}^T) - (Y_t^C - Y_{t-1}^C) \quad (9)$$

The following equation is estimated using OLS to assess the average impact on the treated:

$$Y_{it} = \alpha + \beta D_{it} + \gamma t + \Delta D_{it} t + \eta X_{it} + \varepsilon_{it} \quad (10)$$

with two times period,  $t \in \{0,1\}$ . Period zero indicates a time before the health accident (pre-treatment period), that is, designating observations from 2011, and period one indicating observations from 2017 (post-treatment observation).  $D_{it}$  is binary,  $d \in \{0,1\}$  and indicates if the individuals belongs to the treatment group (if he/she experienced a stroke or a heart attack between 2011 and 2017).  $X_{it}$  is a vector of exogenous observable variables influencing the outcome variable. Chosen variables must not be impacted by the treatment variable as some behavioral assumptions are supposed to hold conditionally to the use of these covariates (Lechner

2010). Standard errors  $\varepsilon_{it}$  are clustered at the individual level to control for the serial correlation (Cameron and Miller 2015).

### 3.4 Robustness

Using a DiD approach requires to formulate assumptions in order to be sure to identify the causal effect of the treatment, the heart attack or the stroke. The first one is the stable unit treatment value assumption (Rubin 1977): the treatment is clearly attributed and observable for part of the population, and there is no interaction between treated and no-treated. The saving or dissaving conditions should not be modified for individuals because some of them will be treated (i.e. will experience a health event). The following hypothesis is tightly linked to the previous one: it requires that the treatment has no effect on the pre-treatment population. Individuals must not change their behavior because they anticipate the treatment. We assume that this is the case with the type of accident we have chosen. The unpredictable nature of the health event considered in the present study allows to reasonably assume that this hypothesis is true. On the contrary, the occurrence of long-term illnesses can be prevented insofar as many incentives for screening exist from the age of 50 in France. In addition, preventive measures are mostly free of charge, and individuals are all the more inclined to undergo regular preventive examinations if their family history shows the need for close monitoring.

The common trend is the key assumption in a DiD approach. This assumption states that individuals who experienced a health event and those who did not would have had the same decumulation trajectory, conditional on the observable variables  $X$ , if the health event had not occurred for some of them. This is closely related to the need for unobserved heterogeneity to be time invariant. Controlling for unobserved heterogeneity can be achieved by ensuring statistical comparability between individuals with and without health events in period zero, so that changes in the objective variable in period 1 cannot be a function of the difference between the two populations (Khandker et al. 2010). To ensure the statistical comparability between treated and untreated, we perform a propensity score matching on the base year before conducting a DiD on the observations that remain in the common support. Combining both approaches leads to a better match between treated and control group in the pre-treatment period. Individuals experiencing a health accident and those not experiencing a health accident nevertheless had the same probability of having a cardiac event or stroke. By proceeding in this way, one realizes first that 78 observations (39 individuals, each observed in 2011 and 2017) have to be dropped to balance the observable characteristics between both groups, treated and untreated.

Although the occurrence of a heart attack or stroke is inherently unpredictable, it cannot be ruled out that the health trajectory of individuals is partly responsible for the health event. If this is the case, the results could suffer from omitted variable bias and compromise the validity of the conclusions. This is the problem of initial conditions (Khandker et al. 2010): the initial conditions in the period before the health event may influence not only the outcome, in this case the assets of individuals, but also the assignment to treatment, i.e. whether or not they are victims of such an event. To address this problem, we implement a fixed effects estimation in another way: the variables, dependent and control, are taken in differences. Then we estimate the initial

model using the differences variables as well as the level variables, keeping only the first period observations. Thus, with a restricted sample, we propose a model taking into account not only the evolutions between both periods (pre-treatment and post-treatment) but also the initial conditions thanks to the level variables.

### 3.5 Results

The results are presented in table 2. Columns 1 to 4 reports the results of the usual DiD, columns 5 and 6 refer to the estimate restricted the observations in the common support of propensity score density after matching, and column 7 reproduces the results with control of the initial conditions. The three methods used converge towards identical results. We disentangle three different marginal effects: the impact of selectivity in the occurrence of a health accident through the variable *health accident*, the impact of the trend (*Time period*), and finally the effect of the effective health event through the interaction term (*health accident x Time period*). The dummy variable *health accident* identifies who belongs to the treatment group in period 1 and 2, even if the stroke or the heart accident occurs between period 1 and period 2.

We assume that the survival probability depends on both the occurrence of the health accident (*health accident x Time period* variable) and the accident-prone terrain (*health accident* variable). See Figure 1 in Appendix). Co-morbidities and subsequent cardiac events have indeed a well-known impact on the probability of survival after the accident (Dupre and Nelson, 2016; Go et al., 2014; National Center for Health Statistics (US), 2014).

At the ages studied, the trend is clearly towards decumulation as time fixed effects have a significant and negative impact. This result is valid for both risky and safe assets. The occurrence of a health shock has a statistically significant impact on safe financial assets held, while it does not have on risky assets. This last result is in line with the theoretical results: the risky assets depend on the relative return and not on the survival probability.

Our empirical results are also consistent with *another result* of the theoretical model: a lower probability of survival leads to a lower level of non-risky savings. The interpretation of the results is not immediate insofar as the health accident appears twice in the estimated model. If we refer to columns 1 and 2, we can see that without a control variable, the marginal effect of belonging to the group of health accident victims (the treated) is -22,375 euros, meaning that before the shock occurs, in  $t = 0$ , people who will have a heart accident or a stroke have, on average, safe savings that are 22,375 euros lower than those who will not have a health accident (See effect *A* on the Figure 1 in appendix). If we take into account control variables (Column 2), this marginal effect is -22,332.5 euros. Here there is a significant difference in the level of safe assets between the treated and untreated groups in the pre-treatment period.

The effective occurrence of the health event (a heart event or a stroke) reduces the gap between treated and untreated as the coefficient of the interaction term is positive (See effect *B* on the Figure 1 in appendix). The global marginal effect of the survival probability is obtained by combining the coefficient of the interaction variable and the treatment group variable as survival probability after this type of shock depends on the shock itself and on the pre-existing health conditions (Dupre and Nelson, 2016; Go et al., 2014; National Center for Health Statistics (US), 2014). In the post-treatment period, the health accident leads then to a decrease in safe



savings of 3,488.97 euros (column 1 and effect  $C$  on the Figure 1 in appendix). The marginal effect considered is  $\frac{\partial Y_{it}}{\partial D_{it}} = \beta + \Delta t$ . In  $t = 1$ , the marginal effect is 18,886.3-22,375.27. If we take into account control variables, the effect is -3,597.51. We therefore confirm the result obtained from the theoretical model: if the survival probability decreases because of a cardiovascular pathology, the optimal accumulation of safe assets decreases.

The empirical approach nevertheless allows to detail the impact of the health event more precisely: if the overall effect is negative, it is composed of two elements, namely the difference in the level of safe assets between people subject to cardiovascular pathology and the others, and the pure effect of the accident. Indeed, if people who suffer a cardiovascular pathology have lower safe savings, they are also led to recompose their portfolio in favour of non-risky assets, as shown by the positive coefficient before the variable *health accident x Time period*.

Moreover, the shock itself does not seem to have a significant impact on health care consumption, which we approximate by the number of medical visits in the 12 months preceding the survey (See column 9). The variable *health accident x Time period* is not significant. However, the difference of health care consumption comes more from a permanent poorer state health as belonging to the treated group increases in average the number of medical visits by 1.14. In other words, the recomposition of individuals' portfolios that follows the occurrence of a shock and the change in the probability of survival is not explained by an increase in post-accident health care consumption.

Our results confirm the intuition put forward by the theoretical model: the occurrence of a health accident, such as a stroke or heart attack, and therefore the presence of a cardiovascular pathology, leads individuals to use their secure savings, which can then be used to supplement health insurance and thus acts as an insurance against health risks.

We also wanted to test whether there might be differences in behaviour between individuals with and without children. The existence of bequest motive could for example imply different results for different subsamples. We therefore restricted the sample to individuals with children (adults themselves, given the age of our sample). This sample contains 5006 observations, i.e. 2533 individuals. The results are provided in the appendix (Table 3). If we consider the most complete models (2nd and 4th column), we note very similar results, indicating here again a decumulation trend for individuals with a cardiovascular pathology, but a recomposition of the portfolio when the shock such as the stroke or the heart attack occurs. This recomposition is in favour of safe assets. The marginal effect of having a cardiovascular pathology is -2,320.48 euros, compared to the 3,488.97 we found for the entire sample (On average, the safe savings of individuals without cardiovascular disease and with children reached 50,100 euros in 2011, while those of individuals with cardiovascular disease and children reached 28,878, which is relatively close to the figures observed for the whole sample in table 1). This marginal effect includes a positive impact of the shock (18,842.92) and a negative effect of the accident prone terrain (-21,163.4). Risky savings decreases over time but does not seem to be affected by the shock itself.

Let's now look a little more precisely at the results after matching. We want to make sure that we have statistically comparable samples in terms of exogenous observable attributes. Then we assume that for comparable individuals, the onset of the cardiac accident is random. We

compare two different types of individuals that diverge only in terms of survival probability: they have the same observable characteristics, except that some of them experience a health accident. The results after matching are reported in columns 5 and 6. Only 78 observations are deleted from the control group to ensure the statistical comparability between both samples (Table 4 in appendix). The control variables are not statistically different between individuals who experienced a heart attack or a stroke and those who did not<sup>5</sup>. The common support of propensity score density is not very large as the probability to experience a health event remains quite low according to the observable characteristics in the pre-treatment period, victims of health accident and control group are statistically comparable for a probability of treatment comprised between 3.59% and 23.55% (Figure 2 in appendix). The results are confirmed: experiencing a health event has no impact on risky assets, while the marginal effect on safe savings is negative and significant. Finally the impact remains significant for safe assets when controlling initial conditions (Columns 7 and 8).

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<sup>5</sup> The mean age can be considered as statistically different between controls and treated for a threshold at 8.4%

Table 2: Estimate of Risky and non-risky assets ( $y_i$ )

|  | Difference in differences  |                            |                          |                           | DiD with PSM               |                           | With initial conditions    |                            | DiD                        |
|--|----------------------------|----------------------------|--------------------------|---------------------------|----------------------------|---------------------------|----------------------------|----------------------------|----------------------------|
|  | Safe assets                | Safe assets                | Risky assets             | Risky assets              | Safe assets                | Risky assets              | Safe assets                | Risky assets               | Number of medical visits   |
|  | 1                          | 2                          | 3                        | 4                         | 5                          | 6                         | 7                          | 8                          | 9                          |
| Health shock x Time period                     | 18886.3***<br>(5408.853)   | 18734.99***<br>(5305.809)  | -1673.892<br>(1490.69)   | -1572.306<br>(1492.917)   | 18495.01***<br>(5302.659)  | -1602.331<br>(1493.28)    |                            |                            | 1.143498<br>(.89375)       |
| Time period                                    | -36808.29***<br>(3171.862) | -40263.66***<br>(2920.021) | -2917.259***<br>(460.74) | -3326.04***<br>(446.2024) | -39755.8***<br>(2905.527)  | -3285.539***<br>(447.261) |                            |                            | -1.006179***<br>(.1811802) |
| Health shock                                   | -22375.27***<br>(4968.396) | -22332.5***<br>(4770.895)  | 90.06644<br>(1514.529)   | 511.8499<br>(1510.516)    | -21926.45***<br>(4767.347) | 525.9584<br>(1510.727)    |                            |                            | 1.970185**<br>(.6256841)   |
| $\Delta$ (Health shock x Time period)          |                            |                            |                          |                           |                            |                           | 17985.43*<br>(10007.01)    | -2413.419<br>(1510.058)    |                            |
| $\Delta$ Has a partner                         |                            |                            |                          |                           |                            |                           | -33105.76***<br>(10913.87) | -4130.673**<br>(1646.904)  |                            |
| $\Delta$ Retired                               |                            |                            |                          |                           |                            |                           | 8213.309<br>(8962.251)     | -311.8325<br>(1352.405)    |                            |
| Has a partner                                  |                            | -20752.1***<br>(5191.894)  |                          | -1096.717<br>(715.3201)   | -20372.36***<br>(5175.085) | -1072.648<br>(714.4147)   | 23374.68***<br>(6834.123)  | 1577.622<br>(1031.27)      | .1259647<br>(.2631482)     |
| Age  |                            | 1224.788<br>(2002.285)     |                          | 826.9228**<br>(303.9919)  | 892.7959<br>(2196.402)     | 729.0967*<br>(326.4333)   | 1093.296<br>(4264.845)     | 287.5939<br>(643.5656)     | -.359831*<br>(.1657387)    |
| Age squared                                    |                            | -6.076185<br>(13.69927)    |                          | -5.514465**<br>(2.036195) | -4.079086<br>(15.00152)    | -4.845362*<br>(2.189508)  | -8.812167<br>(30.82383)    | -2.137364<br>(4.65132)     | .0032318**<br>(.0011898)   |
| Women  |                            | -7601.236<br>(3996.151)    |                          | -1264.422<br>(662.4791)   | -6987.812<br>(3981.055)    | -1228.777<br>(661.5597)   | 13883.67**<br>(6073.726)   | 625.2323<br>(916.5259)     | .7826761**<br>(.2737884)   |
| number of years of education from 6 years old  |                            | 3215.295***<br>(533.4294)  |                          | 725.3761***<br>(121.2691) | 3338.295***<br>(554.9775)  | 744.6773***<br>(124.6555) | -3235.997***<br>(818.4841) | -602.6318***<br>(123.5093) | -.0306539<br>(.0380705)    |
| Retired  |                            | -1248.857<br>(4000.113)    |                          | -1068.103<br>(853.099)    | -907.6963<br>(4043.71)     | -1005.126<br>(866.0066)   | 5410.707<br>(10936.68)     | 1664.96<br>(1650.346)      | -.110313<br>(.0380705)     |
| Constant                                       | 51249.43***<br>(3131.451)  | -20277.14<br>(70955.94)    | 5414.104***<br>(424.902) | -30899.72**<br>(10978.4)  | -9700.13<br>(77520.48)     | -27712.69*<br>(11721.06)  | 6.125941***<br>(141243.2)  | 15.46301**<br>(21313.61)   | 15.46301**<br>(5.721544)   |
| R-squared                                      | 0.025                      | 0.041                      | 0.006                    | 0.026                     | 0.041                      | 0.026                     | 0.016                      | 0.014                      | 0.027                      |
| n  | 2785                       | 2785                       | 2785                     | 2785                      | 2768                       | 2768                      | 2785                       | 2785                       | 2785                       |
| N  | 5570                       | 5570                       | 5570                     | 5570                      | 5536                       | 5536                      | 2785                       | 2785                       | 5570                       |
| Significance levels : * : 10% ** : 5% *** : 1% |                            |                            |                          |                           |                            |                           |                            |                            |                            |

Source : SHARE, Waves 4 & 7 for France

Reading grid: Columns 7 and 8, the variations between the two waves are estimated, which implies that the number of observations is equal to the number of individuals.

## 4 Conclusion

In an economy with imperfect markets and risky assets and uncertain lifetime, we showed that a reduced survival probability implies a lower safe wealth. But the holding of risky assets is not affected by the probability of survival. If the agent anticipates a lower life expectancy because of a heart attack or a stroke, it implies a higher discount to future utilities. This is one less reason to save.

The SHARE survey data support this result but provide a nuance. Indeed, since the descriptive study of the data shows that the populations suffering from a health accident and those not suffering from one are not identical in terms of both observable and unobservable characteristics, we used a double difference method. This method makes it possible to control for selectivity in the occurrence of a health shock, even if it appears unpredictable by nature. It also allows us to distinguish the pure marginal effect from the occurrence of the health accident after it has happened.

Having a health accident such as a stroke or heart attack leads to a decrease in safe savings, even if this decrease actually conceals two contradictory effects: on the one hand, a decrease due to the cardiovascular pathology (selection effect), and on the other hand, an increase due to the occurrence of the accident itself (shock effect). The first effect prevails, which shows that, in the end, long-term health status seems to be predominant in the probability of saving, particularly in safe assets, i.e. annuities in our life cycle model.

Being able to save in annuities is essential to offer individuals the possibility to absorb the consequences of poor health. Depending on the architecture of the social security systems, this will be likely to complement health insurance when the public system is not protective enough. These results are relatively consistent with the American literature which shows that health shocks can have a significant impact on the savings of older adults, especially for those with low savings or chronic health conditions (De Nardi et al. 2009, Heflin and Pattison 2012, De Nardi et al. 2016). But we also distinguish between risky and non-risky savings, which had not been done by these pioneer articles. In the case of France, the issue of private financing of health care is less crucial since social security protects individuals with long-term illness. Among the 5% of insured persons with the highest health expenses, the rate of health insurance coverage was 94% in 2017. For insured persons with median expenditure levels, the coverage rate was 56%. However, the out-of-pocket expenses for elderly can remain substantial, particularly for visits to specialists and hospitals (DREES, 2022).

As our results show, the occurrence of a stroke or heart attack (shock effect) does not seem to increase the demand for care. However, suffering from a cardiovascular pathology (selection effect) does increase it. In France, in 2019, 37% of people aged 75 or over suffered from cardiovascular pathologies (coronary disease, heart failure, rhythm disorders). The frequency of cardio-neurovascular diseases doubles compared to younger age groups (37% for 75 years old and over versus 18% for 65-74 years old and 9% for 55-64 years old), and the risk of decompensation also increases significantly with age (heart attack, stroke, pulmonary embolism or decompensation for heart failure) (DREES, 2022). With the aging of the population, it is therefore necessary to offer households attractive opportunities to save securely over the long term, not only to supplement the state pension, as is common in many countries, but also to cope with the consequences of poor health. This type of safe asset then complements the coverage

provided by compulsory health insurance, whether for poorly reimbursed health expenses or for related expenses linked to poor health (living environment, support for relatives in poor health, etc.).

Our twofold theoretical and empirical approach has enabled us to illustrate and explore the mechanisms at play when a health accident occurs and impacts on savings behaviour at old ages. Our reflection focused mainly on the analysis of choices between risky and non-risky assets in order to fully exploit the results of the life cycle model. Nevertheless, the size of our sample did not allow us to analyse the impact of the bequest motive in greater depth, as we did not have sufficient observations without children. This aspect of the question can therefore be used in future research. In addition, the savings data used in this paper are expressed per capita within households. But it should not be overlooked that there are also inequalities between men and women, both in terms of wealth and health, which could lead us to extend our research by exploring the effects of gender. Over the past few decades, various health concerns have indeed arisen that are particularly significant for women having a higher prevalence of rheumatic and musculoskeletal diseases (RMDs). As a consequence, women have been found to be more susceptible to heart disease (Guerrina and al. 2021). An extended research could be conducted on gender inequalities in health and savings insofar as women are saving less than men and earning and old-age pension in 2020, 40% less than men (DREES 2022), their health-care at older ages could be very challenging.

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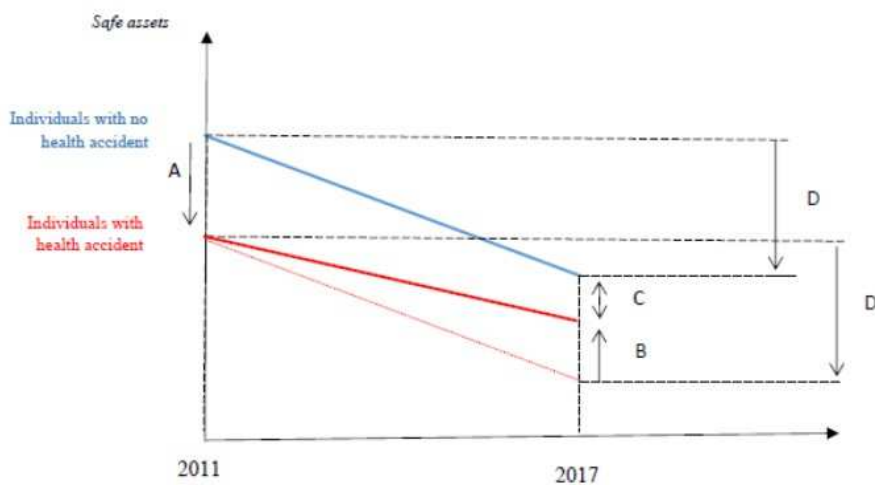
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## 5 Appendix

Figure 1: Theoretical and empirical approaches: what they bring



A : Wealth gap between people with and without a health event (different health trajectories, leading to different accumulation, and leading to the occurrence of a health event), period before the health event. Negative impact. (See variable *health accident*)

B : Pure effect of the shock: individuals recompose their savings in favor of precautionary savings. Difference between what individuals would have saved without the shock and their actual savings after the shock. Positive impact. (See variable *health accident x time period*)

C : Wealth gap between people with different probabilities of survival (due to the occurrence of a stroke or cardiac event), after the event has occurred.  $A+B=C$ .

D : Time effect for individuals without health accident (See variable *time period*)

The theoretical model identifies C, and the empirical approach disentangles A, B, C and D.

*! on this figure, the shock occurs in 2011, but in the data, it occurs between 2011 and 2017 !*

Table 3: Estimate of Risky and non-risky assets ( $y_i$ ) for individuals with children

|  | Safe assets  | Safe assets  | Risky assets | Risky assets |
|--|--------------|--------------|--------------|--------------|
| Health shock                                   | 18772.5**    | 18842.92***  | -795.1409    | -624.6739    |
| x Time period                                  | (5872.298)   | (5718.228)   | (1050.346)   | (1049.805)   |
| Time period                                    | -36763.38*** | -39448.34*** | -2897.402*** | -3418.552*** |
|  | (3351.934)   | (3061.237)   | (478.8588)   | (473.0941)   |
| Health shock                                   | -21222.01*** | -21163.4***  | -653.0462    | -303.3541    |
|  | (5327.84)    | (5128.683)   | (1097.822)   | (1076.159)   |
| Has a partner                                  |              | -22530.39*** |              | -1337.876    |
|  |              | (6376.258)   |              | (855.7788)   |
| Age  |              | 1589.289     |              | 947.6582**   |
|  |              | (2023.192)   |              | (304.9003)   |
| Age squared                                    |              | -10.17107    |              | -6.350805**  |
|  |              | (13.57518)   |              | (2.046614)   |
| Women  |              | -9996.274*   |              | -1228.444    |
|  |              | (4562.054)   |              | (712.1153)   |
| Number of years of education from 6 years old  |              | 3035.548***  |              | 742.9018***  |
|  |              | (551.2017)   |              | (130.2142)   |
| Retired  |              | -111.9332    |              | -856.0391    |
|  |              | (4105.304)   |              | (879.7699)   |
| Constant                                       | 50100.41***  | -22440.19    | 5364.864***  | -35298.1**   |
|  | (3329.935)   | (73169.39)   | (441.591)    | (10925.85)   |
| R-squared                                      | 0.025        | 0.040        | 0.006        | 0.028        |
| N  | 5066         | 5066         | 5066         | 5066         |
| Significance levels : * : 10% ** : 5% *** : 1% |              |              |              |              |

Table 4: Statistics for controls and treated observations

|                              | Controls |         | Treatment |        | Difference |           |
|------------------------------|----------|---------|-----------|--------|------------|-----------|
|                              | n        | mean    | n         | mean   | $t$        | $p >  t $ |
| Has a partner                | 2509     | 0.64737 | 259       | 0.6139 | -0.79      | 0.431     |
| Age                          | 2509     | 66.46   | 259       | 67.98  | 1.73       | 0.084     |
| Women                        | 2509     | 0.5723  | 259       | 0.5675 | -0.11      | 0.913     |
| Number of years of education | 2509     | 11.22   | 259       | 10.83  | -1.25      | 0.213     |
| Retired                      | 2509     | 0.6559  | 259       | 0.6911 | 0.85       | 0.395     |

Figure 2: Propensity scores density

