Individual uncertainty on longevity*

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Abstract

The aim of this paper is to provide an assessment of individual uncertainty regarding length of life. For that purpose, we have collected original data through a survey performed in 2009 on a representative sample of 3,331 French people aged 18 or more. The survey design recorded several survival probabilities per individual, which makes it possible to compute (i) the subjective life expectancy (SLE), defined as the first moment of the individual's subjective distribution relative to his personal longevity; (ii) the standard error of this distribution, which provides insight on the individual's uncertainty regarding his own longevity (IUL). In addition, the survey provided detailed information on objective health indicators (illnesses and disabilities), as well as a subjective indicator such as self-assessed health (SAH). We show that there is a considerable between-individual variability in subjective life expectancies. This heterogeneity is partly explained by age, illnesses, risky behavior, parents' death and socioeconomic variables (with estimated impacts of illnesses and risky behaviors showing that people are rational in adjusting their expectations with illnesses and lifestyle). But the bulk of subjective life expectancy variability remains unexplained: from a standard deviation equal to 9.32 years (women), the residual of an estimation including an extensive list of regressors show a standard deviation equal to 8.02 years. We find that the individual uncertainty relative to length of life is quite large, equal on average to more than 10 years for men and women. It is close to 15 years for people around 40 and still equal to 10 years for people around 55. It is logically decreasing with age. Outside age, a very few variables explain this uncertainty. Our estimates show that unobserved heterogeneity linked with more pessimism regarding length of life is connected with higher uncertainty. Our main result is the extent of individual uncertainty regarding length of life. This huge individual uncertainty is observed together with a large inter-individual variability of subjective life expectancies.

These results have important consequences for issues regarding public health and retirement policies. Indeed, individual uncertainty about longevity affects prevention behaviors, retirement decisions, pension plan choices, and demand for long-

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term care insurance. Taken together, the great individual uncertainty and the great between-individual variability of expectations may justify the public outrage at the prospect of raising the retirement age. For many young people, this substantially increases the subjective probability of having a short or non-existent retirement.

1 The importance of subjective life expectancies

Until recently, the prevailing practice in econometric analysis of choice data has been to assume that decision makers have specific expectations that correspond to the reality, in other words assume rational expectations (Manski, 2004). As concerns survival probabilities, it is of major importance to question this standard rational expectation assumption. Information on subjective life expectancies might provide better understanding of intertemporal decision making by individuals: retirement decisions, pension plan choice, demand for long term care insurance, as well as prevention behavior and risky lifestyle.

In addition, objective information as provided by life tables is rather limited, especially because they give very few information about interindividual heterogeneity in life expectancy. They provide information on life expectancy by gender and age only, while own health, parent longevity and health behavior have an influence on the individual's life expectancy. Besides, it is important to know how unsure people are about their length of life at the individual level. This is likely to be of major importance to understand, for instance, demand for annuities, and prevention behavior.

1.1 Literature

Many papers analyse survival expectations and subjective survival probabilities. Some of the data used in the literature result from direct questions on expected longevity (Hamermesh & Hamermesh, 1983, Hamermesh, 1985, Mirowsky, 1999; Mirowsky and Ross, 2000; Brower *et al.*, 2005). Other studies rely on subjective survival probabilities collected by Health and Retirement Study (HRS), or by the Survey of Health, Ageing and Retirement in Europe (SHARE) or other surveys (Hurd and McGarry (1995), Liu, Tsou and Hammit (2007), Hurd (2009), Peracchi and Perotti (2011), Delavande & Rohwedder (2011), Kutlu-Koc and Kalwij (2013)).

In general, the studies make use of cross sectional or longitudinal data to examine relation between illnesses or illness onset and subjective survival probabilities. The results show that individuals make rational adjustments: illnesses have negative impact on survival probabilities and subjective survival probabilities are correlated with death rates observed afterwards in longitudinal data. Parent death appear to have an impact on subjective survival probabilities, especially same sex parent. In most papers women report smaller survival probabilities than men, despite their larger actuarial probabilities. Longitudinal data make it possible to see how probabilities are updated when there is new information (like the onset of one illness), and to examine the correlation between probabilities and corresponding outcomes observed in subsequent waves. Hurd (2009) and Delavande & Rohwedder (2011) show that expectations are well correlated with outcomes.

1.2 Purpose of the paper

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For that purpose, we have collected original data through a survey performed in 2009 on a representative sample of 3,331 French people aged 18 or more. The survey design recorded several survival probabilities per individual, which makes it possible to compute (i) the subjective life expectancy (SLE), defined as the first moment of the individual's subjective distribution relative to his personal longevity; (ii) the standard error of this distribution, which provides insight on the individual's uncertainty regarding his own longevity (IUL). In addition, the survey provided detailed information on objective health indicators (illnesses and disabilities), as well as a subjective indicator such as self-assessed health (SAH).

We show that there is a considerable between-individual variability in subjective life expectancies. This heterogeneity is partly explained by age, illnesses, risky behavior, parents' death and socioeconomic variables (with estimated impacts of illnesses and risky behaviors showing that people are rational in adjusting their expectations with illnesses and lifestyle). But the bulk of subjective life expectancy variability remains unexplained: from a standard deviation equal to 9.32 years (women), the residual of an estimation including an extensive list of regressors show a standard deviation equal to 8.02 years.

We find that the individual uncertainty relative to length of life is quite large, equal on average to more than 10 years for men and women. It is close to 15 years for people around 40 and still equal to 10 years for people around 55. It is logically decreasing with age. Outside age, a very few variables explain this uncertainty. Our estimates show that unobserved heterogeneity linked with more pessimism regarding length of life is connected with higher uncertainty.

Our main result is the extent of individual uncertainty regarding length of life. This huge individual uncertainty is observed together with a large inter-individual variability of subjective life expectancies, which appears to be realistic. Indeed, it is of the same magnitude than the inter-individual variability of observed longevities that we can measure on an extinguished cohort.

2 Data

2.1 The survey

We used original data coming from a survey that we have performed in November and December 2009. The questionnaire was designed to elicit subjective survival probabilities as well as expectations regarding health and income. The data is a cross section of 3,331 individuals aged 18 or more, that are representative of the corresponding French population, except that we manage to have an over representation of people aged 50 and more.[1] Indeed, we needed enough observations of people affected by illnesses, in order to draw relevant statistical inference as concerns the impact of illnesses on self assessed health and expectations regarding survival. Of course, all computations and estimations are weighted to obtain results that can be held as representative of the French population. Our survey was performed face to face, with a computer-assisted personal interviewing (CAPI)

[1] In comparison with the age structure of the population, we chose to double the proportion of age categories of people aged 50 or more in our sample.

technique. The interview duration was about 45 minutes. A preliminary pilot survey was performed on 30 respondents to avoid misunderstanding and improve the questionnaire wording.

The questionnaire first contains questions on age, gender and socioeconomic variables, such as education, individual and household income as well as insurance coverage. A lot of attention is devoted to health status, with detailed questions on conditions that might affect the individual, self-assessed health, and the individual's lifestyle (smoking, drinking, height and weight to compute a body mass index). Then the questionnaire makes it possible to elicit subjective survival probabilities and subjective joint distributions of income and health for future decades.[2] In addition, it allows for an evaluation of the individual's willingness-to-pay for being in perfect health, which makes it possible to calculate his/her equivalent income as a measure of well-being (Fleurbaey and Schokkaert, 2012; Fleurbaey and Blanchet, 2013, Fleurbaey *et al.*, 2013, Schokkaert *et al.*, 2014). To sum up, this survey provides a very rich information on individual trade-offs between income and health, as well as on individal expectations relative to three dimensions: income, health and longevity. While the present paper focuses on subjective expectations relative to longevity, its conclusions will be put into perspective with the results derived from our other investigations.

2.2 Elicitation of subjective survival probabilities

Our strategy to elicit subjective survival probabilities follows Hurd and McGarry (1995) and Lui, Tsou and Hammitt (2007). Respondents are asked about their chance of being alive after a given age. Considering a person younger than 51, the first question is the following:

« In your mind, what is the percent chance that you will live beyond the age of 50? »

A scale is submitted to the respondent, who has to choose between 14 figures: 0 % 5% 10 % 15 % 20 % 25 % 30 % 40% 50 % 60 % 70 % 80 % 90 % 100 %.

Only one answer was allowed; "don't know" or "refusal" answers were allowed.

Once the respondent had answered to the first subjective survival question, he or she was asked the same question again but for "more than 60", then "more than 70", etc. up to "more than 90". In total, respondents younger than 51 were asked five subjective survival questions, people between 51 and 60 were asked four survival questions and people between 81 and 90 one survival question only. In the survey design, follow-up questions are constrained: probability values strictly greater than the answer given to the previous question are not proposed. Therefore, subjective survival probabilities are weakly decreasing with age, by construction. Our subjective life expectancy indicator (2) can be computed only for individuals that answered all survival questions. Removing all individuals who gave at least one protest answer ("don't know" or "refusal") to one of the survival questions, our final sample consists of 2,856 individuals. In the following, we check if our conclusions might be affected by a selection bias.

Denote x_i the age at death of respondent i ($x_i = i$'s length of life). For a person younger than 51, five probabilities are recorded:

$$\begin{aligned} &p_{1,i} = \Pr(x_i > 50), \ p_{2,i} = \Pr(x_i > 60), \ p_{3,i} = \Pr(x_i > 70), \\ &p_{4,i} = \Pr(x_i > 80), \ p_{5,i} = \Pr(x_i > 90) \end{aligned} \tag{1}$$

[2]For instance, an individual aged 50 is supposed to face five possible life decades : from 51 to 60 years old, 61 to 70, ..., 91 to 100. The probability to survive beyond 100 is set to zero.

We use the raw information provided by subjective probabilities to compute subjective life expectancy for each respondent on the basis of four assumptions:

Assumption 1: All respondents will live up to 40: $P(x \geq 40) = 1$.

Assumption 2 : Respondents who have reached the age of 100 will die within the year: $P(x > 100) = 0$.

Assumption 3: If the respondent is supposed to die in a given decade, he/she is supposed to die at the average age of death observed for men/women dying within the corresponding decade in the population.[3]

Assumption 4: As for the current decade, the death probability is uniform over the remaining years. For instance, a 53 year old respondent lives in average 3.5 years if he/she dies before 61.

Consider a male respondent i aged between 41 and 50. His subjective life expectancy is computed as follows:

$$\begin{aligned} SLE_i = E_i(x) = P_i(40 < x \leq 50)b_i + P_i(50 < x \leq 60)56.01 \\ + P_i(60 < x \leq 70)65.92 + \quad P_i(70 < x \leq 80)76.05 \\ + P_i(80 < x \leq 90)85.54 + P_i(90 < x \leq 100)93.73 \end{aligned} \tag{2}$$

where $b_i = (50 - age_i)/2$ and

$$\begin{aligned} P_i(40 < x \leq 50) = 1 - p_{1,i};\ P_i(50 < x \leq 60) = p_{1,i} - p_{2,i}; \\ P_i(60 < x \leq 70) = p_{2,i} - p_{3,i}; \text{...and } P_i(90 < x \leq 100) = p_{5,i}. \end{aligned} \tag{3}$$

The subjective life expectancy (SLE_i) is defined as the first moment of $i's$ subjective distribution relative to his personal longevity. Interestingly, having recorded several survival probabilities for the same individual enables us to compute the variance of this distribution, which provides insight on $i's$ uncertainty regarding his own longevity. One has:

$$V_i(x) = \sum_j p_{ij}(x_j - E_i(x))^2 \tag{4}$$

where p_{ij} is the subjective probability of death in decade j (x_j being the age of death as given in Assumption 3). For the respondent considered above (a male between 41 and 50 years old), this variance is given by:

$$\begin{aligned} V_i(x) = P_i(40 < x \leq 50)(b_i - E_i(x))^2 + P_i(50 < x \leq 60)(56.01 - E_i(x))^2 \\ + \quad P_i(60 < x \leq 70)(65.92 - E_i(x))^2 + P_i(70 < x \leq 80)(76.05 - E_i(x))^2 \\ + \quad P_i(80 < x \leq 90)(85.54 - E_i(x))^2 + P_i(90 < x \leq 100)(93.73 - E_i(x))^2 \end{aligned} \tag{5}$$

[3] Indeed the mortality law, especially for very old people, prevent us a linear interpolation to compute the average death age within each decade. Hence we used observed death rates displayed by the French National Demography Institute for year 2009. More precisely, instead of 55, 65, ...and 95, we used the following average death age within each decade: for men younger than 41 dying within 41-50: 46.30 years; for men between 51 and 60 years old : 56.01 years; for men between 61 and 70 years old :65.92 years; for men between 71 and 80 years old : 76.05 years; for men between 81 and 90 years old : 85.54 years and for men between 91 and 100 years old, 93.73 years. For women the corresponding figures are the following : 46.26 years, 55.94 years, 66.07 years, 76.35 years, 86.07 years and 94.22 years.

Hereafter, the corresponding standard deviation will be used as an indicator of the individual's uncertainty regarding his/her own longevity. We call this variable "individual uncertainty on longevity". It is denoted IUL and defined by:

$$IUL_i = \sqrt{V_i(x)}\ . \tag{6}$$

2.3 Information on health

Our survey includes detailed questions on specific diseases that the respondent might have experienced in the previous 12 months. The questionnaire derives from a list of 15 groups of questions (eg. respiratory diseases, cardio-vascular diseases, ...) taken from the *Enquête Santé et Protection Sociale* (Health and Social Protection Survey) of IRDES (Institute for Research and Information in Health Economics). On the whole, 45 illnesses are recorded plus other diseases resulting from « open » declarations that were allowed for: the corresponding *verbatim* were recoded in ICD10 thanks to expert assessments by doctors. There are also questions on disability in the last 12 months, measured by activity limitations, such as having difficulty to walk or in everyday activities, being bed ridden, or suffering from pain**.**

At the end of that section came a question on self-assessed health (SAH_i):

« In the last questions, you have indicated your health problems over the last 12 months. With your answers in mind, please evaluate your level of health on the last 12 months with this scale from 0 to 100. 0 is equal to death and 100 indicates the best possible health given your age»

So, our survey provides a subjective measure of health and detailed objective indicators relative to illnesses and disabilities. Given the very large number of illnesses observed, we decided to classify them according to two criteria: whether they are chronic or not, and whether they might threaten life in the short run or not. As a result, we obtain the following four categories:

- N: Illnesses that do not shorten or threaten life (for example: lumbago)
- A: Acute illnesses → immediate death risk (depression)
- C: Chronic condition → reduction in the length of life, but no immediate death risk (hypertension, diabetes)
- AC: Acute and chronic → immediate death risk and length of life reduced (asthma, myocardial infarction)

Hereafter, these categories are referred to as *vital risk variables.* The coding of illnessses, including the answers to open questions, has been performed by a group of three doctors.[4]

Our motivation to create the vital risk categories relies in the fact that we want to examine the link between illnesses, SAH and subjective life expectancy. SAH is generally considered a good predictor of death risk. But the link between SAH and death risk might be more complex. As shown by Case and Paxson (2005), women have worse SAH and more hospitalization than men but lower death rates. Actually, gender difference in SAH

[4]Their methods and results are described in Bahrami *et al.* (2011).

is entirely due to the distribution of chronic conditions women face. These conditions are painful and deteriorate the quality of life (arthritis, lumbago, anxiety, etc.) but do not threaten life like heart diseases for instance. More prevalent for men, heart diseases are not so painful, but have a large impact on death rates.

3 Descriptive analysis

3.1 Basic features of the data

The general features of the data are displayed in table 1. Means are computed for men and women separately, for all the explanatory variables used in our econometric specification. The sample is the one used for the estimation of a three-equation model, where all variables, including SAH, SLE and IUL are observed for each individual. For each variable the p-value of the test for difference in average levels between men and women is given.

The socio-demographic characteristics confirm that the sample is representative of the French population, as concerns education, income and coverage by health insurance (Schokkaert *et al.* 2014). In France there is a mandatory National Health Insurance that covers care only partially. To improve coverage, people can subscribe a complementary health insurance, mostly on a voluntary basis. Free complementary health insurance, named $CMUC$[5] is provided to people who are very poor, the eligibility level of income for $CMUC$ being much lower than the poverty level.[6] We observe in table 1 that a small minority of respondents, 5 to 7 %, are covered by the National Health Insurance only (i.e. don't have a complementary health insurance) which is close to the proportion observed for the whole French population. Similarly, the proportion of CMUC beneficiaries is in our sample close to the proportion observed in the whole population.

As stated above, we have summarized all the objective information relative to illnesses by vital risk variables. An illness can be of type N (do not shorten or threaten life), A (acute), C (chronic) or AC (acute and chronic). Table 1 shows that women are more affected than men by illnesses of type N, that spoil life without shortening it: they are 53 % to have 3 or more illnesses of type N, in contrast with 36 % of men. Women have also significantly more acute diseases (type A) than men. Otherwise, we do not observe any significant difference between men and women in the prevalence of chronic (C), as well as acute and chronic (AC) diseases. Figure A.1 in appendix A gives a more accurate picture of the same results, with proportions by age and gender for each type of illness, as well as confidence intervals by age. The figures concerning all indicators relative to disability also show that women are significantly more often affected by activity limitations and pain than men.

As concerns lifestyle, we find that women are more "virtuous": they are smokers or drinkers in significantly smaller proportions than men (see Table 1 and Figures A.2 and A.4). On the other hand, the proportion of people who are obese, severely obese, or with normal weight is not significantly different between men and women (table 1 and A.3). A significant difference is observed for overweight, which is more frequent for men (34 %) than for women (22 %), and for underweight, which is rather rare altogether, but more frequent for women (5 % versus 1% for men).

[5] $CMUC =$ *Couverture Maladie Universelle Complémentaire.*

[6] Depending on whether the poverty level is defined as being equal to 50 % or 60 % of the median income, the eligibility income level for $CMUC$ is equal to 88 % or 73 % of the poverty level.

The litterature on subjective survival probabilities uses information on parent death as potential explanatory variables (Hurd and McGarry, 1995; Lui, Tsou and Hammitt, 2007). The figures displayed in Table 1 show that there is (obviously) no difference between men and women as regards parent death. Otherwise, it is noteworthy to observe that half of the respondents have lost their father, while two-thirds of them still have their mother. This gives a striking picture of mortality differential between men and women. Our respondents are well aware of this mortality differential, at least as concerns their parents.

3.2 Subjective survival probabilities

Figures 1 and 2 display for men and women our raw information, i.e. the distributions of survival probabilities $p_{1,i}$, $p_{2,i}$,..., $p_{5,i}$ defined by (1) and given by the respondents. Figure 1 give the probabilities for people of all ages below the target, and figure 2 gives the probabilities for people close to the target age, whose age is less than ten years below the target age. Our subjective probabilities are affected by a variability due to (i) differences between individuals as concerns their objective characteristics, including age; (ii) differences between individuals as concerns their assessment of longevity (pessimism or not); (iii) individual uncertainty regarding their longevity.

Figures 1 and 2 are rather similar for men and women. They show the wide variability of subjective survival probabilities. The variability is somewhat reduced when focusing on people close to the target age in figure 2, but not that much: it is still sizeable for any target. While there is a clear mode at 1 for younger ages, the spread is visible for target ages beyond 70. When they get older than 70, people have very different assessments about their survival chance.

In a survey devoted to the use of on subjective probabilities in research, Hurd (2009) states that many results suggest that there is a bias towards 50 %. Actually, the distributions in figure 2 for target ages equal to 80 and 90 show a mode at 0.5. If there is a bias of subjective probabilities towards 50 %, respondents should understate the true probability when the latter is greater than 50 %, and overstate the true probability when it is lower than 50 %. To examine the average bias, we have computed the differences $p_{j,i,a} - \overline{p}_{j,a}$, $j = 1, ..., 5$ for each individual i, where $p_{1,i,a}$, $p_{2,i,a}$,..., $p_{5,i,a}$ are the individual subjective probabilities defined by (1) for each individual of age a, and where $\overline{p}_{1,a}$, $\overline{p}_{2,a}$, , $\overline{p}_{5,a}$ are the corresponding survival probabilities given for men and women of age a by life tables in 2009.[7] Figure 3 gives the mean differences by age for men and women. In contrast with the histograms, this doesn't show between individual variability, but gives an appraisal of the average mistake for each requested probability p_1, p_2,..., p_5. The average mistake of male respondents are consistent with Hurd's suggestion, with an understatement for p_1 to p_4 and an overstatement for p_5. Indeed, the values of $\overline{p}_1$ to $\overline{p}_4$ are greater than 50 %, while $\overline{p}_5$ is clearly lower than 50 %, even for men aged more than 80, where it is equal to 44 %. Female respondents systematically underestimate all survival probabilities: their life table probabilities are greater than 50 %, except for $\overline{p}_5$, which is however equal to 55 % for women aged more than 80. Interestingly, the bias are diminishing for all subjective probabilities when the respondent's age approaches the target (except for the male

[7] Notice that we have not adjusted the life tables to take into account the likely increase in longevity. Actually, people might be aware of this possibility. But we focus mostly on the individual variability in assessments rather than on their accuracy with respect to the "true" future longevity.

octogenarians who are increasingly optimistics with age).

3.3 Subjective life expectancy and individual uncertainty on longevity

Figure 4 shows the distributions by age groups of indicators SLE_i and IUL_i, defined by (2), (5) and (6). The subjective life expectancy (red histograms) has a strikingly between individual variability, especially for people aged 60 or less. This variability is smaller for older age groups, whom are asked a reduced number of survival probabilities.[8]

The variable IUL_i gives information on the level of uncertainty of *each individual* regarding his/her own longevity. We are mostly interested in the mean or median level of this variable. Remember that IUL is defined as a standard deviation: it has the same unit of measurement than SLE, i.e. number of years. In comparison with the median level of subjective life expectancy (77, 80 to 90, depending on the age group), the median of IUL appears to be very large, around 13 years for people below 51, 10 years for people below 61 and 7 years for people below 71. Quite logically, uncertainty on longevity is decreasing with respondent's age: when he/she is getting further on his/her survival curve, the range of possible values for longevity is indeed decreasing, leading to a decrease in the standard deviation. This is embodied in our specification of IUL (5) and (6), where the number of survival probabilities used in the computation is decreasing with age.

Figure 5 displays the average SLE, as a function of respondent age, for men (blue continuous line) and women (red continuous line). The curves derive from nonparametric adjustments on a polynomial function of age.[9] They show that the subjective life expectancy is increasing with age. While they survive to older ages, individuals update their expectancies and give a higher probability to a longer life. The dotted lines on figure 5 give the life table life expectancies provided for year 2009 by the French National Institute of Demography: it is computed by using the mortality rates observed in year 2009 for each generation. Since it is computed on the whole population, no variability affects this statistic: there is no confidence interval.

As shown in figure 5, there is a large gender gap affecting LE computed for the whole population (doted lines). Actually, France is one of the countries with the largest gender gap in life expectancy at birth. It amounts to 6.7 in 2010, while it is for the same year equal to 3.9 in the United Kingdom, 5 in the USA and 6 in Japan. This gap is both due to a rather high female LE at birth (84.8, at the third rank worldwide after Japan and Spain in 2010) and a rather low male LE at birth (78.1, at the 14th rank worldwide).

This gender gap is not reflected in our subjective LE: figure 5 shows that male and female SLE are very close at every age. Actually, there is a slight and significant difference between women and men only when they are 40 to 55 years old.

Another important feature of our subjective life expectancies is that male and female both understate their LE, in comparison with life tables LE (doted lines). The understatement decreases with age. It is significantly different from 0 until the age of 70 for

[8] Remind that people of the first age group are asked five survival probabilities, the second four survival probabilities, then three, ..., until one for the last group, namely people aged 81 and more.

[9] For the purpose of legibility, we provide in figure 5 the confidence interval of the average SLE for men only.

men and almost always significant for women.[10] The female understatement is much larger, close to – 10 years for women younger than 40. So, women understate their LE much more than men. As a result, their SLE appear to be close to men's SLE, while they actually live on average much longer than men. That women are more pessimistic than men is a result quoted in many papers studying subjective survival probabilities (Hurd and McGarry, 1995; Lui, Tsou and Hammitt, 2007, Hurd, 2009). It is found also in Mirowsky (1999), who examines direct assessments of longevity.

To check the robustness of our results we used French data from SHARE, wave 2. The survival questions of SHARE are not the same as in our survey: only one survival question is asked to each individual, about the probability to live ten more years, with a target age, which is equal to 75, 80, 85, 90 or 95, depending on the respondent's age. As in our sample, we find that people understate strongly their survival probabilities and that there is no significant difference between men and women as concerns the probability to live ten more years.[11]

As shown by figure 6, the between individual variability in subjective life expectancies is quite large: the standard deviation of SLE is equal to 10 years for people aged 35-40. It is slightly decreasing with age, but still equal to 6 years for people aged 60-65. One can wonder if this variability correctly reflects the true inequality in longevity between people. Actually, it is possible to measure the longevity variability only on data relative to a "dead cohort", which can provide information on the age at death for all the individuals belonging to this cohort. Using data from the French National Institute of Demography, we have computed the standard deviation of ex post observed lengths of life of French people born in 1900. Figure 7 gives the between individual standard deviation of longevity for people born in 1900 that have survived until the age given on the horizontal axis. The result is strikingly close to the curve obtained in figure 6, suggesting that the large between individual variability in subjective life expectancies reflects beliefs that are quite realistic.[12]

Figure 8 shows the mean by age of indicator IUL_i which measures the individual's uncertainty on his/her own longevity. This indicator does not measure the same phenomenon as the between-individual variability of SLE_i shown by Figure 6. However, there is a link between the two concepts. Indeed, people might base their uncertainty in observing the variability in age at death for their familie and close relations. Conversely, the variability of SLE_i is partly influenced by IUL_i. It depends on differences between individuals as concerns their objective characteristics and the way they assess their longevity. The way they build their assessment is influenced by their education (potential knowledge in demography), pessimism or not, and uncertainty regarding their longevity (IUL_i).

The individual uncertainty in longevity appears to be not significantly different between men and women. As explained above it is, quite logically, decreasing with age. The most noteworthy result is the magnitude of average IUL: it is close to 15 years for young

[10] Notice that the understatement is likely to be even more important than what appears on the figure: the official statistics itself understate the LE of a given generation because it is computed on the basis of mortality rates observed in one year for every generation.

[11] Detailed results are available on request.

[12] This variability is measured on a cohort of people who experienced the first and second world wars. For the cohorts for which it can be computed, it does not seem to change much over time: for people born in 1856, the overall longevity standard deviation for people who survived to at least 40 is equal to 12.7, for cohort 1886, it is equal to 13.7, for cohort 1900 it is 13.9 and for cohort 1910 we obtain 13.6.

people (around 40) and still equal to 10 years for people around 55 (figure 8)! Remember that this indicator is a standard deviation for subjective longevity, whose median level of expectation (SLE_i) lies between 77 and 90. The level of uncertainty seems considerable, when people have to take decisions on savings, and perhaps make a sacrifice, to improve their income in the older ages.

Our econometric analysis will examine the determinants of SLE, IUL and of the self-assessed health (SAH), which is also a subjective assessment requested by the survey. Figure 9 displays the average self-assessed health by age. As expected, it is continuously decreasing with age (the peak near 90 for men is due to a very small number of people and non significant). As in Case and Paxson (2005), women set their SAH at a lower level than men on average. This difference appears to be significant for women younger than around 55.

Table 2 gives, for SAH, SLE and IUL the means and standard deviations, as well as the p-value associated to the test for difference of the means between men and women. The same figures are given for the gap between SLE and life table life expectancies. This table summarizes the main conclusions of our descriptive analysis: SAH is significantly lower for women than for men; the average SLE is about 78 - 77 years, slightly higher for women; the standard deviation of SLE is quite large, indicating a large between individual variability; the average IUL is very large, above 10 years, showing the importance of uncertainty that affect individual expectations on longevity; the magnitude of this uncertainty appears to be similar for men and women; both men and women understate their life expectancy, with a much larger understatement for women.

4 Econometric analysis

4.1 Empirical specification

We estimate for women and men separately a simultaneous equation model explaining the individual's self-assessed health, subjective life expectancy and uncertainty on longevity:

$$\begin{array}{ll} (I) & SAH_i = VR_i\ a + X_{1,i}\ b + Z_i\ c + u_{1,i} \\ (II) & SLE_i = SAH_i\ \gamma + VR_i\ \alpha + X_{2,i}\ \beta + u_{2,i} \\ (III) & IUL_i = SAH_i\ \gamma' + VR_i\ \alpha' + X_{2,i}\ \beta' + u_{3,i}\ , \end{array} \tag{7}$$

with $(u_{1,i}\ \ u_{2,i}\ u_{3,i})' \sim (0, \Sigma)$ where Σ can be a non-diagonal matrix.

The three dependent variables are explained by the set of vital risk variables VR_i ,i.e dummy variables characterizing the number of diseases of type N (do not shorten or threaten life), A (acute), C (chronic) or AC (acute and chronic). We didn't include the detailed list of diseases in the regression since vital risk variables provide a more synthetic information. Indeed, diseases are not significant when they are included in the regression in addition to vital risks.

In equation (I), SAH_i is also explained by (i) $X_{1,i}$, which includes a quadratic function of age, socioeconomic variables (education, income and insurance coverage) and variables characterizing the individual's lifestyle, (ii) and by Z_i , the functional limitations, and pain, experienced by the individual. SLE_i and IUL_i are explained by the subjective and objective indicators of health, SAH_i and VR_i and by a set of regressors $X_{2,i}$, which contains the variables $X_{1,i}$, and information about the individual's parent death and age of death. Following Hurd & McGarry (1995) and Lui, Tsou & Hammitt, (2007) we suppose that individuals might use this information to assess their own longevity. We introduce for each parent four categories: alive, death age ignored by the respondent, death age greater or lower than the respondent's age. We supposed that the information on individual's parent death and age of death doesn't influence SAH and this was confirmed by preliminary regressions. Variables $X_{1,i}$, $X_{2,i}$, VR_i and Z_i are supposed to be exogenous, which is reasonable as concerns health indicators, but more questionable for lifestyle variables.

We didn't consider logarithmic transformations of the dependent variables. Indeed the distributions of SAH_i, SLE_i and IUL_i are rather close to normal distributions, according to the values of their skewness and kurtosis, at least closer than their logarithmic transformations.[13] The disturbances $u_{1,i}$ $u_{2,i}$ and $u_{3,i}$ are likely to capture unobserved heterogeneity that might explain SAH_i, SLE_i and IUL_i: individual's information on health (hereditary diseases) or lifestyle not recorded in the survey, heterogeneity in pessimism/optimism or in the personal weights given to vital risks and lifestyle, for instance, to form the self assessment of health and survival probabilities. Our specification allows for correlations between the three disturbances, i.e. for the possibility that unobserved determinants might be common for SAH_i, SLE_i and IUL_i.

Our simultaneous equation model is recursive, at least as concerns equations (I) and (II) or (I) and (III) : SAH is an explanatory variable of SLE_i and IUL_i, while these two variables are not supposed to influence SAH. This structure is in line with the survey design, where questions about diseases and self assessed health are asked before the survival probabilities. It might be possible that individual expectations regarding longevity influence self assessed health. But it seemed rather unlikely to us. So, it appeared more reasonable to adopt a recursive model with SAH explained first: it is close to the survey design and it avoids the identification difficulties that would arise with a non recursive model.

We have to deal with two econometric issues. Firstly, SAH_i can be non exogenous in equations (II) and (III). To test for its exogeneity, we performed $2SLS$ estimations of equations (II) and (III). Actually, our four indicators of functional limitations and pain, Z_i , appear to be appropriate excluded instruments for SAH_i. Indeed, they are explanatory variables of SAH_i but have no direct influence on SLE_i and IUL_i: they are not significant when introduced in equations (II) and (III). Moreover, they are well correlated with SAH_i (no weak instrument problem[14]) and their exogeneity is not rejected by the Sargan test.[15]The results of first-step estimations and tests for men and women are detailed in the appendix, table A.1. With these validated instruments, the Haussman tests led to non rejection of SAH_i exogeneity for the SLE_i and IUL_i equations (at least

[13]One has, for SAH_i, SLE_i and IUL_i respectively, skewness $= -1.12$, 0.7 and 0.14 ; kurtosis $= 4.38$, 3.2 and 2.37. When taking the log transformations the kurtosis is greater than 20 for $\log(SAH_i)$ and $\log(IUL_i)$ and the skewnesses are still negative and further from 0.

[14]Following Bound *et al.* (1995) we check the weak instrument possibility by computing the Fisher statistics for the significance of the Z_i in the first stage regressions. They are equal to 21.4 for women and 17 for men, respectively. Given that we use 4 instruments, this rules out a lack of correlation of them with SAH.

[15]The p-values for the Sargan statistic are respectively 0.21 and 0.22 for women and men.

for men as concerns the latter).[16] As a consequence, we did not use an instrumental variable method to estimate equations (II) and (III). Notice that the exogeneity of SAH can be confirmed by a lack of correlation between the disturbances of equations (I) and (II) and of equations (I) and (III). This is the result effectively obtained (see bottom of table 3).

Secondly, about 15% respondents did not give all the survival probabilities requested to compute their SLE and level of uncertainty. Looking at their characteristics, we find that the individuals who did not give complete answers are slightly older and have a lower level of SAH. We used the Heckman two step approach to deal with a possible selection bias. The first step regressions (separate for men and women) estimate the probability to answer to all the requested survival questions. Age, education and visit to a GP were included as explanatory variables for participation, as well as the information on parents' death and a self assessed level of happiness in some complementary regressions. Actually, the inverse Mills ratios obtained from these first steps were never significant when included in equations (I), (II) and (III).[17]

We conclude from these investigations that a GLS estimator, i.e. allowing for heteroskedasticity and correlations between the disturbances of equations (I), (II) and (III), can provide efficient estimates of our three-equation model 7.

4.2 Results

Columns 1 of table 3 presents the estimates of equation (I) for women and men. The reader should keep in mind that average SAH is 72 for women and 76 for men (SAH is assessed on a 0-100 scale) in order to appraise the magnitudes of the impacts of vital risks.

These impacts appear to be significant and quite large. Some are valued similarly by men and women: having 2 or more illnesses of type AC (Acute and Chronic, such as myocardial infarction or tumor) "costs" 7.6 points for women and 5.9 points for men; having at least one illness of type A (Acute, such as depression, phlebitis or pulmonary embolism) "costs" 8.2 points for women and 9.0 points for men. It is worth noticing that functional limitations have a significant negative influence on SAH (except being bed-ridden), even in a regression where vital risks are controlled for. Women and men evaluate rather identically the impact of functional limitations, but women ascribe a higher impact to pain.

More differences appear between women and men as concerns illnesses of type N (do not shorten or threaten life, such as tinnitus, lumbago or arthritis): having 1 or 2 of these illnesses decreases the assessment by women of their own health by 5.8 points, having 3 or more of such illnesses decreases women SAH by 10.2 points. The corresponding values are much lower for men: 3.1 and 6.7 points. There is also a difference between women and men as concerns the valuation of illnesses of type C (Chronic, such as hypertension or diabetes). In this case, men ascribe a higher cost than women do: having 1 illness of type C decreases the health assessment by men by 3.9 points, having 2 or more of such illnesses decreases men SAH by 9.0 points. The corresponding values are much lower for

[16] P-value associated with the Hausman test statistic are, for the SLE equation 0.45 for women and 0.27 for men; for the IUL equation, they are respectively equal to 0.04 for women and 0.06 for men. The exogeneity of SAH is debatable for women in the IUL equation.

[17] Results are available on request.

women: 1.9 (non significant) and 5.1 points. It is not easy to interpret these differences in assessments by men and women: it can be due to gender differences in the "pricing" of illnesses; it might derive as well from unobserved gender differences in the seriousness of illnesses.

The influence of lifestyle variables on SAH show that women and men are aware of the deleterious impacts of smoking, overweight and obesity on health. Men are a bit more aware as concerns smoking: the estimated loss in SAH is -3.2 points for men and -1.8 points for women. Conversely, women ascribe more losses in SAH for BMI problems. The sole significant impact estimated for alcohol is a positive one: + 2.8 points for a non risky alcohol consumption by women (but not men). Women seem to have well understood the WHO advices relative to the admitted level of alcohol consumption.

Finally, socio economic variables indicating a low social position are connected with a significant lower assessment of the individual's own health: having no diploma for men and women (- 3.5 to - 4 points), a low income level for women (- 3.5 points) or being CMUC beneficiary for men (- 6.4 points).

Results concerning the subjective life expectancy (equation (II) of model 7) are presented in columns 2 of table 3. The average SLE is 78.8 years for women and 77.3 years for men with standard deviations equal to 9.7 for both women and men (see table 2). Individuals take their self assessed health into account when selecting their survival probabilities: SAH has a significant positive impact on subjective life expectancy. A 10 point increase in the level of SAH leads to an increase in SLE of 0.8 years for women and 1.2 years for men. Hence, the estimated impacts of vital risks and life style on SLE are direct impacts that come in addition to indirect impacts coming from their influence on SAH in equation (I).

For women, having one illness of type AC (Acute and Chronic) or at least one illness of type A (Acute) reduces the SLE by 1.3 years. For men illnesses of type AC have no significant impacts on subjective life expectancy, while having at least one illness of type A shortens their SLE by 2.4 years. Interestingly, both women and men ascribe a high loss in life expectancy to having 2 or more chronic illnesses (type C: hypertension, diabetes, etc.): they respectively associate a loss in SLE equal to - 2.6 years and -1.9 years. If we compute the total effect of having 2 or more of these chronic illnesses (direct effect + indirect effect through SAH) one finds a loss of - 3 years for women and men. Another interesting result is that illnesses of type N have no impact on SLE for men and women. Indeed, the survey proposes a list of illness names, like lumbago, arthritis, diabetes, etc.. The categorization in N, C, A or AC has not been communicated to the respondents, nor the information that a given illness does or not shorten or threaten life. The fact that individuals do not adjust their survival probabilities (and, accordingly their SLE) with respect to illnesses of type N, but expect a sizeable reduction for chronic diseases show remarkable knowledge regarding the impacts of illnesses on longevity.[18]

The same rationality in adjustments is observed as concerns the estimated impacts of lifestyle. People are aware that smoking reduces life expectancy, by 1.9 and 2.3 years, respectively, for women and men. Taking into account the indirect impact through SAH, one finds total reductions in SLE equal to 2.1 and 2.7 years, respectively, for women and

[18] In other words, all women have not read Case and Paxson (2005), but they know that they have worse SAH than men but lower death rates, because the conditions they face are painful but do not threaten life like heart diseases.

men. Only men appear to be conscious of the influence of heavy drinking on longevity (reduction in SLE equal to -2.4 years), while men and women have well grasped the idea that a non risky alcohol consumption might be good for longevity (a gain of 1.2 years for both sexes[19]). Otherwise, individuals do not have in mind that a high BMI could shorten life (however, we have seen that men and women lower their SAH when they have BMI problems). More surprising, obese women expect 1.7 more life years than the other women.

Some studies have shown that the longevity of same-sex parent has an influence of the individual's survival probabilities (see for instance Lui *et al.,* 2007). Here we find a different result: the longevity of the mother only impacts individuals' declarations, especially if the age of the mother's death is unknown (it causes a decrease in SLE of 4.1 years for women and 3.7 years for men). One possible explanation can be linked to changes in habits between generations, especially for men, that used to smoke in rather high proportions in the old generations. In this context, a son could think that the age of his father's death is not a relevant information for his own longevity if he doesn't smoke himself.[20] To check this idea, we estimated the same model on a sample restricted to smokers (these people are likely to have the same attitudes towards tobacco as their parents). The results are provided in table 4: they show significant and large impacts of same-sex parent death for men and women, with larger reductions in SLE if the age of death is unknown, and even larger if the age of death is larger than the respondent's age (- 6.0 years for women, -3.6 years for men). This result has to be confirmed. However it adds another picture about people's rationality in setting their longevity expectations. Indeed, it suggests that the use of information relative to parent death age depends on parent's possible risky behaviors.

Finally, the impacts of socioeconomic variables show that people with low education or low social position are correct in foreseeing a short life for themselves: women with income below 875 € have a reduction in SLE equal to -1.2 years; men that are CMUC beneficiaries have a reduction in SLE of - 3.7 years.

On the whole, our respondents have adjusted their survival probabilities in relation to their illnesses, lifestyle and social position. The resulting variations in their subjective life expectancy correspond to the known impacts on actual longevity measured by epidemiological studies. Our result show that people make the difference between illnesses that threaten life or not and that they somehow internalize the connection between a lower social position and a shorter life. The magnitude of the impact of smoking here estimated (- 2.1 to - 2.7 years) might seem small in comparison to epidemiological results that exhibit a loss in life expectancy equal to 6 years at 50 (and to 3 years at 60). But here, we perform a multivariate analysis: part of the impact of smoking is captured by the impact of education level, income, BMI problems and drinking. Comparing directly the mean SLE between smokers and non smokers, we find significant differences of 5.7 and 5.8 years for men and women, i.e. losses in subjective life expectancies that are consistent with epidemiological results regarding the impact of smoking on actual longevity.

Finally, it is worthwhile to noticing that the bulk of SLE variability remains unexplained: from a standard deviation of SLE equal to 9.32 years for women, the residual of our estimation show a standard deviation equal to 8.02 years (i.e. R^2 is at best equal to 32 %). The same figures are obtained for men.

[19] In France, where there are many wine producers, there is a lot of communication about this idea, together with the warning that heavy drinking is bad for health.

[20] We thank Alain Trannoy who suggest this interpretation.

Results concerning individual uncertainty on longevity are displayed in columns 3 of table 3. We have seen that the magnitude of IUL is considerable: on average it is equal to about 10.5 years for men and women. In contrast with the results obtained for SAH and SLE, few variables impact IUL significantly. Age has a quite logical negative impact, for reasons already discussed above. Otherwise, having diseases of type N increases uncertainty slightly for women, obesity decreases men's uncertainty on their longevity by one year for obese and severely obese men. Having an income below 875 € decreases uncertainty for men (- 1.3 year). Otherwise, it is worth noticing that risky consumptions have no influence on IUL.

The estimates of the correlation coefficients between the disturbances of model 7 are displayed at the bottom of table 3. As expected, $\rho_{1,2}$ and $\rho_{1,3}$ are not significantly different from zero, which confirms the exogeneity of SAH. It suggests that unobserved heterogeneity that contributes to the formation of self assessed health is not correlated with unobserved heterogeneity that influences survival probabilities and hence SLE and IUL. Statements about health seem to be quite something else than statements on longevity[21]: there is no apparent connection between pessimism/optimism for stating SAH and SLE or SAH and IUL. On the other hand, $\rho_{2,3}$ is significant and negative for women and men, suggesting that a lower SLE for given regressors, that we roughly interpret as pessimism for subjective life expectancy, is correlated with a higher individual uncertainty on longevity. This might result from the fact that we compute SLE and IUL under the assumption of bounded longevity (age <=100). Hence more uncertainty imply less longevity, which can be seen as a logical consequence of a natural bound on longevity.

5 Conclusions

This study is based on original data collected through a survey performed in 2009 on a representative sample of 3,331 French people aged 18 or more. The survey design recorded several survival probabilities per individual, which makes it possible to compute (i) the subjective life expectancy (SLE), defined as the first moment of the individual's subjective distribution relative to his personal longevity; (ii) the standard error of this distribution, which provides insight on the individual's uncertainty regarding his own longevity (IUL). In addition, the survey provided detailed information on objective health indicators (illnesses and disabilities), as well as a subjective indicator such as self-assessed health (SAH).

Our analysis shows that women declare a lower self assessed health than men, and that both men and women understate their life expectancy, with a much larger understatement for women. The subjective life expectancies are characterized by a very large between individual variability: for an average SLE equal to 78.8 years for women and 77.3 years for men, the standard deviation is equal to 9.7 for both women and men. The individual uncertainty on longevity is also very large: it is close to 15 years for people around 40 and still equal to 10 years for people around 55; on average it is larger than 10 years, showing the importance of uncertainty that affect individual expectations on longevity; the magnitude of this uncertainty appears to be similar for men and women;

Econometric estimations show that individuals are pretty rational in adjusting their survival probabilities in relation to their illnesses, lifestyle and social position. The re-

[21] As concerns unobserved heterogeneity. Otherwise, individuals use information about their illnesses and SAH to evaluate their survival chances.

sulting variations in their subjective life expectancy correspond to the known impacts on actual longevity measured by epidemiological studies. Our results show that people know the deleterious impact of risky consumptions on health and longevity; in addition, they show remarkable knowledge regarding the various impacts of illnesses on longevity: in particular, they make the difference between illnesses that threaten life or not. Moreover, individuals base their expectations on information that is consistent with the observed correlation between social position and longevity.

Our main result is the magnitude of individual uncertainty on longevity. The sources of such a level of individual uncertainty have to be analysed. It might be a rational assessement based on observed variability in longevity between individuals: people might form their expectations observing the variability in age at death among their family and close relations. This huge individual uncertainty is observed together with a large between individual variability of longevity expectations.

These results have important consequences for issues regarding public health and retirement policies. Indeed, individual uncertainty on longevity affects prevention behavior, retirement decisions, pension plan choices, and demand for long-term care insurance.

Regarding prevention, for instance, people have good knowledge about the fact that they can loose 6 years of life, on average, if they smoke. In a pioneer paper, Hamermesh & Hamermesh (1983) showed that smokers are aware of the detrimental effects of smoking on longevity. They claimed that "the fact that smoking has not ceased entirely reflects people's willingness to take risks, not imperfect information about the effects of smoking." But besides this, they are uncertain about their longevity with a standard error equal to 10 years (for people around 55)! One may wonder if a huge uncertainty on longevity reduces the attractiveness of an increase in life expectancy. In absence of uncertainty, a six-year increase in longevity increases the certainty-equivalent by six years. With background uncertainty, the same increase in expected longevity (keeping uncertainty unchanged) is worth less than six years for the certainty-equivalent if marginal utility is concave, which is the opposite of "prudence" (defined as $u''' > 0$).[22] Risk-averse and sufficiently prudent agents should be more willing to stop smoking when background uncertainty is great. But smokers may be disproportionately imprudent, in which case the opposite effect prevails.

Similarly, income insurance is important, but if people are not sure to live long, this uncertainty may justify their apparent myopia. Why save a lot if you may not live to enjoy it? Our results might shed light on the "annuity puzzle", which is due to the lack of success of annuities in spite of the fact that they insure individuals against the risk of outliving their savings. As recalled in Beshears et al. (2013), the literature has found several possible explanations, such as adverse selection, bequest motives, uncertain healthcare expenses, and the annuity embedded in Social Security and defined-benefit pension plans. Now, if individuals are strongly uncertain about their longevity, and if income support alleviates the danger of dire poverty after exhaustion of savings, the risk of dying early may loom larger than the risk of living too long. In this context, annuities increase the risk of not being able to take advantage of one's wealth, which may look particularly unappealing when people think that, in case of early health warnings, they would like to consume more than planned in the period in which they can still enjoy

[22]The derivative of $CE(\delta) = u^{-1}(Eu(x+\delta))$ w.r.t. δ, at $\delta = 0$, is equal to $(Eu'(x))/u'(CE(0))$. This is less than one if $Eu'(x) < u'(Ex)$, because one always has $u'(Ex) \leq u'(CE(0))$. A sufficient condition is then $u''' < 0$ (which is the opposite of prudence for a risk-averse agent).

certain forms of expensive consumption (e.g., touristic trips).[23] Beshears et al.'s (2013) survey uncovers people's strong desire to remain in control of their wealth, which is completely consistent with their being anxious about an early death.

Taken together, the great individual uncertainty and the great variability of expectations between individuals may explain the public outrage at the prospect of raising the retirement age. For many young people, this substantially increases the subjective probability of having a short or non-existent retirement.

6 References

Bahrami *et al.* (2011) Risque vital associé à la morbidité déclarée, *Cahier de la Chaire Santé*

Beshears J., J.J. Choi, D. Laibson, B.C. Madrian, S.P. Zeldes 2013, "What makes annuitization more appealing?," *Journal of Public Economics*, in press.

Bound J., Jaeger D. A. et Baker R. (1995) : "Problems with Instrumental Variables Estimation When the Correlation Between the Instruments and the Endogenous Explanatory Variables is Weak.", *Journal of the American Statistical Association*, 90, 443-450.

Brouwer, W. B.F., van Exel, N., Job A., (2005). "Expectations regarding length and health related quality of life: Some empirical findings," *Social Science & Medicine*, vol. 61(5), 1083-1094

Case A. and Paxson C. (2005): Sex Differences in Morbidity and Mortality, *Demography,* vol. 42, n° 2, 189-214.

Fleurbaey, M., & Blanchet, D. (2013). Beyond GDP. Measuring welfare and assessing sustainability. Oxford: Oxford University Press.

Fleurbaey, M., & Schokkaert, E. (2009). Unfair inequalities in health and health care. *Journal of Health Economics*, 28, 73_90.

Fleurbaey, M. Luchini, S. Muller C.and Schokkaert, E. (2013), Equivalent income and fair evaluation of health care, *Health Economics* 22: 711–729.

Hamermesh, D.S., Hamermesh, F.W., 1983. Does perception of life expectancy reflect health knowledge? *American Journal of Public Health* 73, 911-914.

Hamermesh, D.S., 1985. Expectations, life expectancy and economic behavior. *The Quarterly Journal of Economics*,100, 389-408.

M. D. Hurd (2009) Subjective Probabilities in Household Surveys, *Annu Rev Econom.* June 1: 543–562

Hurd, M.D., McGarry, K. (1995) Evaluation of the subjective probabilities of survival in the health and retirement study. *The Journal of Human Resources* 30, S268-S292.

Kutlu-Koc V. and Kalwij A. (2013) Individuals' Survival Expectations and Actual Mortality, Netspar discussion paper 05/2013-013

Lui J.-T., Tsou M.-W. and Hammitt J. K. (2007) Health Information and Subjective Survival Probability: Evidence from Taiwan, *Journal of Risk Research,* Vol. 10, n°2, 149-175

Manski, C. F. (2004). Measuring expectations. *Econometrica*, 72, 1329–1376.

Mirowsky, J. (1999) Subjective life expectancy in the US: correspondence to actuarial estimates by age, sex and race. *Social Science & Medicine* 49, 967-979.

[23] This is reinforced if the marginal utility of consumption goes down in very old age. Poverty in very old age is then seen ex ante as a lesser harm than failure to consume when marginal utility is still high.

Schokkaert, E., C. Van de Voorde, B. Dormont, M. Fleurbaey, S. Luchini, A.-L. Samson and C. Thébaut, (2014), Equity in Health and Equivalent Incomes, in Pedro Rosa Dias, Owen O'Donnell (ed.) *Health and Inequality* (Research on Economic Inequality, Volume 21), Emerald Group Publishing Limited, pp.131-156

Vallin J. and Meslé F. (2001), Tables de mortalité françaises pour les XIXe et XXe siècles et projections pour le XXIe siècle, INED, Données statistiques n°4-2001

Figure 1: Distribution of subjective survival probabilities, men and women of all ages below the target

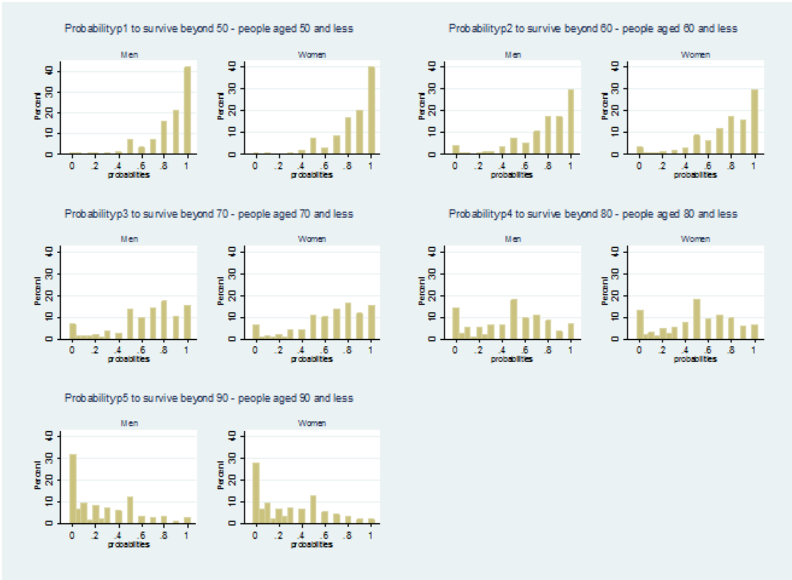

Figure 2: Distribution of subjective survival probabilities, men and women of ages close to the target (max 10 years)

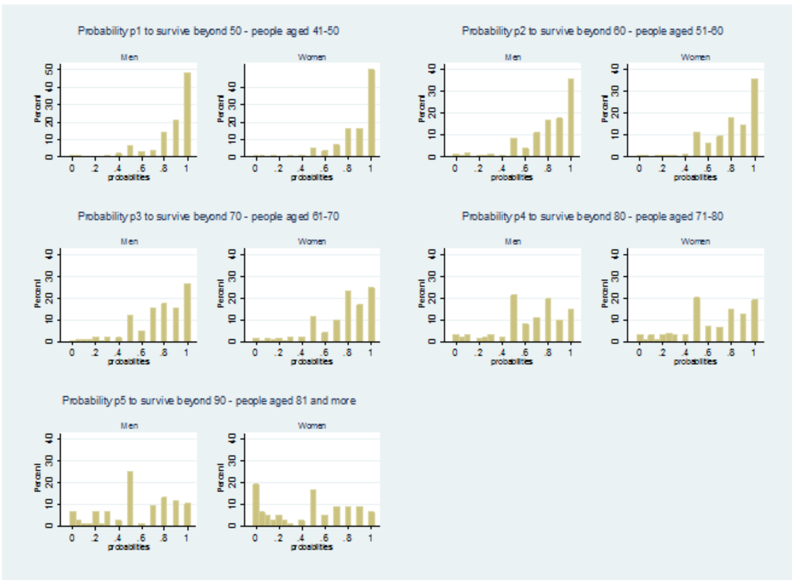

Figure 3: Average difference by age, between subjective survival probability and life table probability

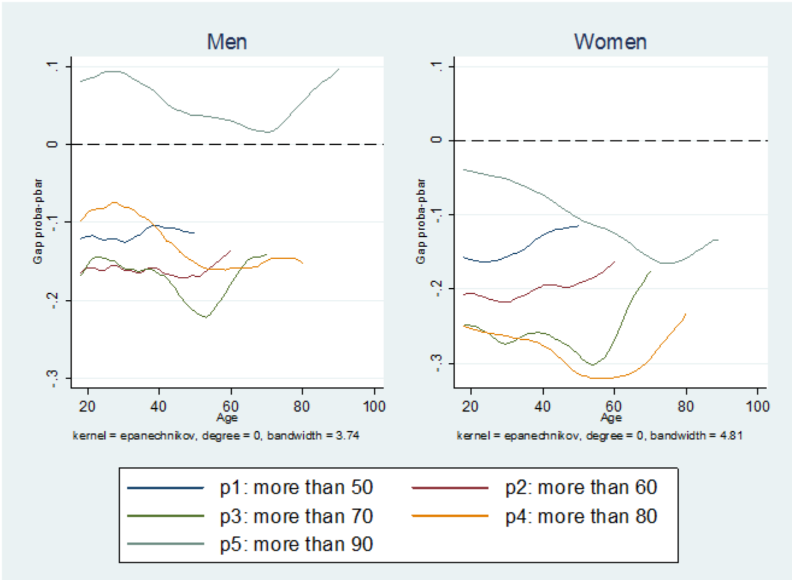

Figure 4: Distribution of SLE and IUL by age groups

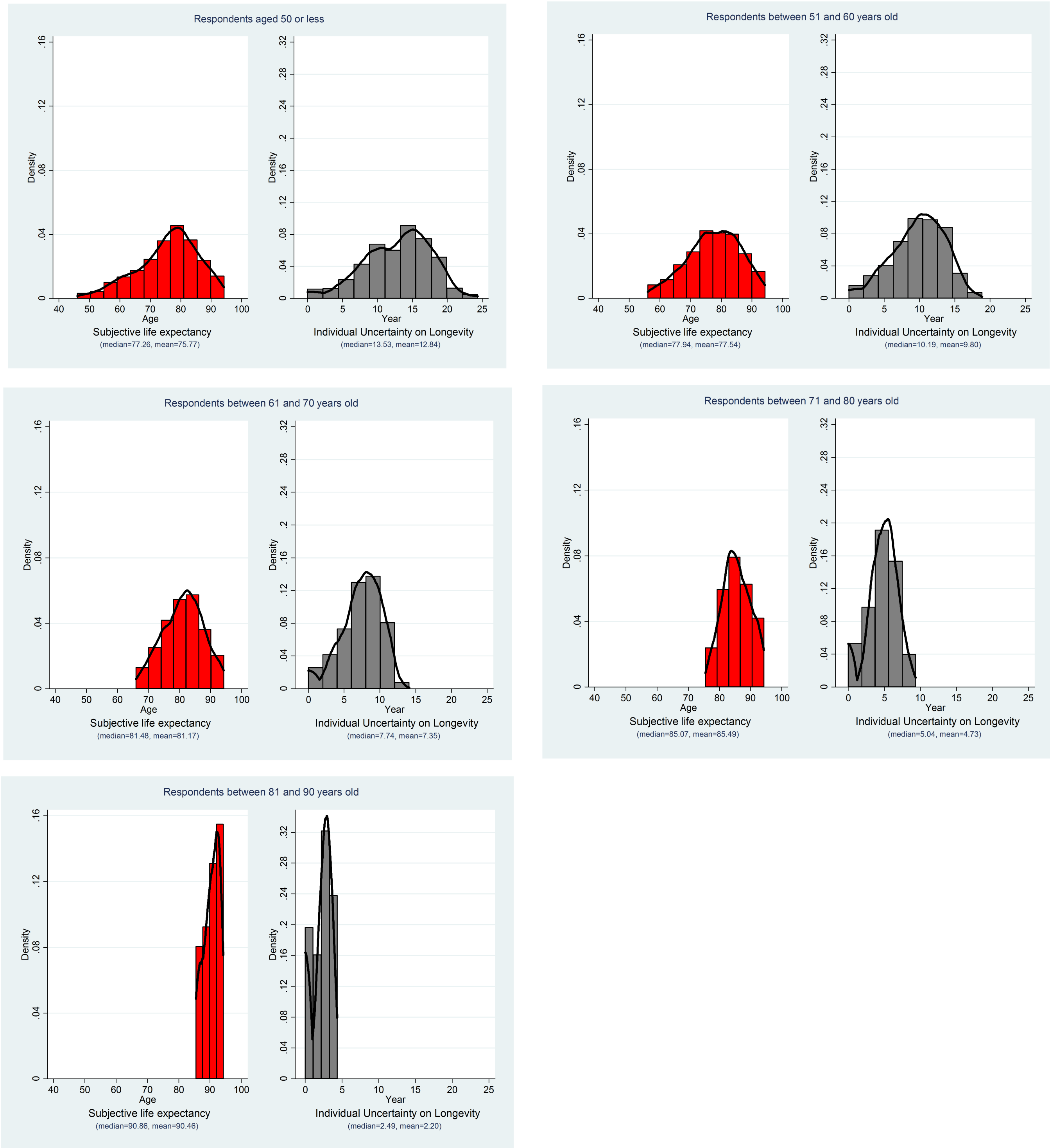

Figure 5: Average SLE and life table LE by age

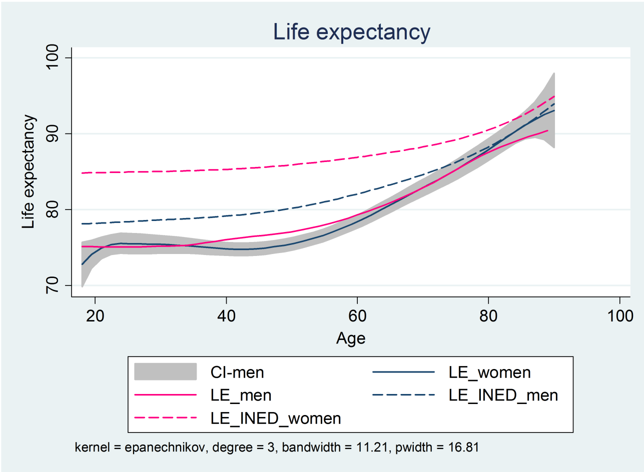

Figure 6: Between individuals variability in SLE (standard deviation by age groups)

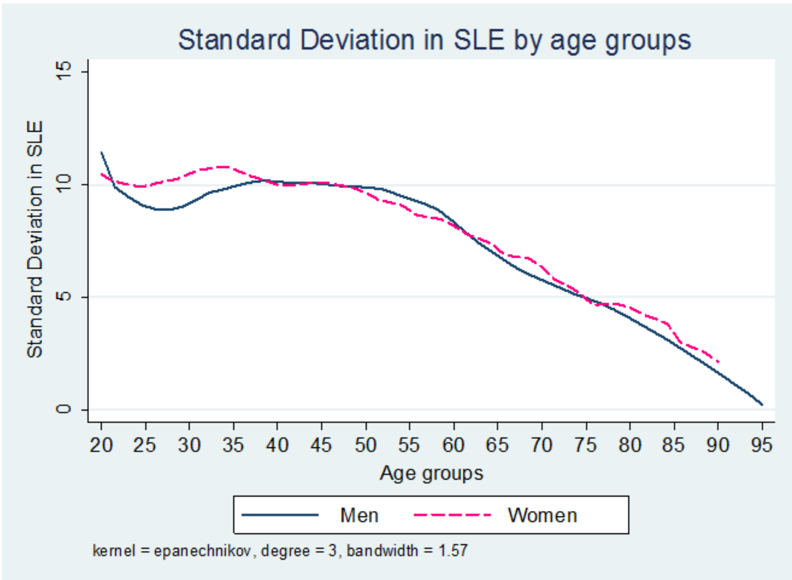

Figure 7: Standard deviation of individual longevity observed on a dead cohort

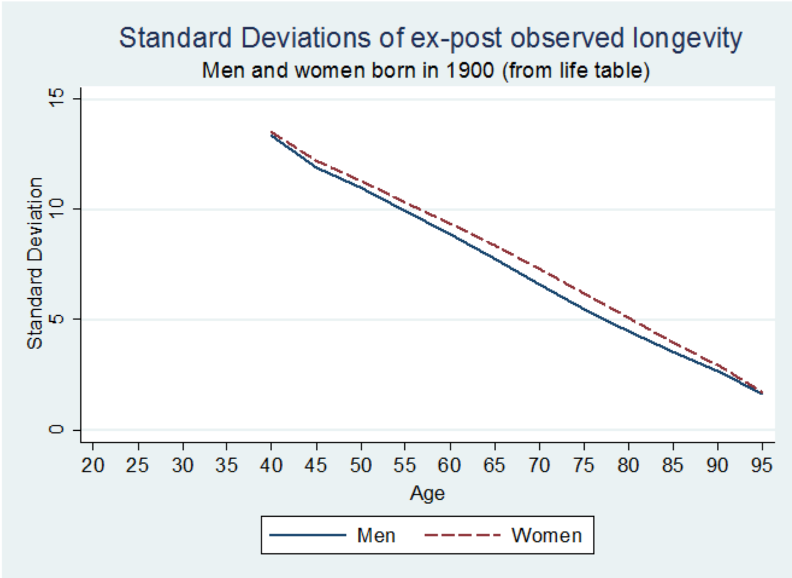

Figure 8: Average Individual Uncertainty on longevity (IUL)

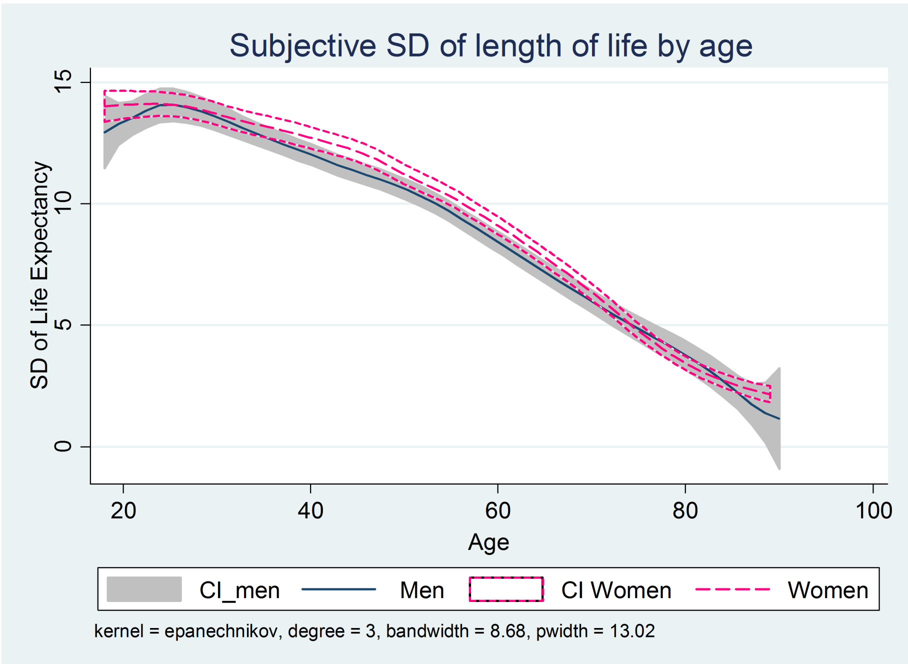

Figure 9: Average Self Assessed Health (SAH)

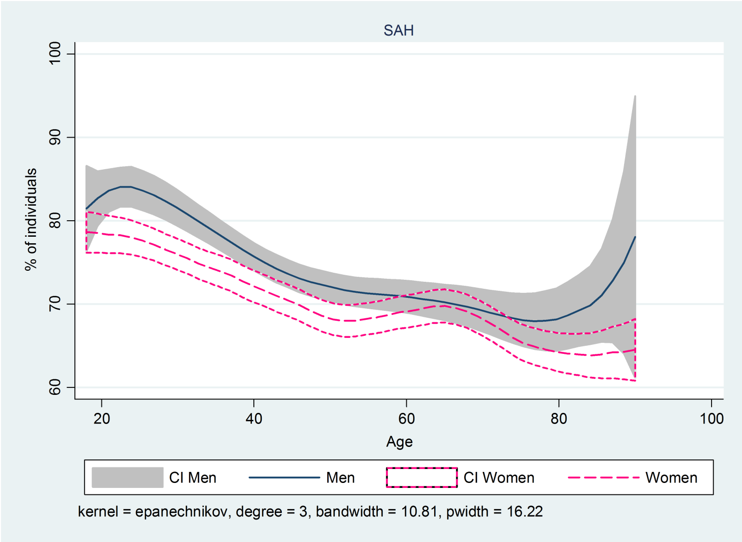

Table 1: General features of the data

		Women	Men	p-value
Socio-demographic characteristics				
Age	Age	47.75 (18.56)	46.61 (17.62)	0.1156
Gender	Gender	0.52	0.48	0.0000
Education	No diploma	0.12	0.08	0.0018
	Primary School certificate	0.12	0.09	0.0027
	GCSE	0.34	0.40	0.0033
	Baccalauréat	0.16	0.17	0.7696
	University $\leq$ 2 years	0.13	0.11	0.0482
	University $\geq$ 3 years	0.13	0.16	0.0327
	Other diploma	0.001	0.002	0.4262
Income	Income $\leq$ 875 €	0.29	0.21	0.0000
	Income $\in [875 - 1290]$ €	0.26	0.23	0.1668
	Income $\in [1290 - 1800]$ €	0.24	0.27	0.0558
	Income $>$ 1800 €	0.21	0.28	0.0000
Health Insurance	National Health Ins. only	0.05	0.07	0.0183
	Complementary Ins.	0.88	0.87	0.3228
	CMUC only	0.06	0.05	0.0454
Family Situation	Marital life	0.55	0.62	0.0002
	At least one child	0.45	0.35	0.0000
Health				
Vital Risks	0 illness of type N	0.14	0.22	0.0000
	1-2 illnesses of type N	0.33	0.42	0.0000
	$\geq$ 3 illnesses of type N	0.53	0.36	0.0000
	0 illness of type AC	0.80	0.83	0.0334
	1 illness of type AC	0.16	0.13	0.0293
	$\geq$ 2 illnesses of type AC	0.04	0.03	0.7942
	0 illness of type A	0.87	0.93	0.0000
	$\geq$ 1 illnesses of type A	0.13	0.07	0.0000
	0 illness of type C	0.68	0.68	0.9345
	1 illness of type C	0.21	0.21	0.7283
	$\geq$ 2 illnesses of type C	0.10	0.11	0.5204
Functional Limitations	Difficulties to walk	0.17	0.12	0.0001
	Bed-ridden	0.12	0.09	0.0026
	Difficulties in everyday activities	0.21	0.14	0.0000
	Pain	0.39	0.32	0.0008
Lifestyles	Smoker	0.32	0.40	0.0001
	Underweight	0.05	0.01	0.0000
	Normal weight	0.51	0.49	0.2392
	Overweight	0.22	0.34	0.0000
	Obese	0.11	0.09	0.2512
	Severely obese	0.07	0.06	0.2046
	No alcohol	0.34	0.19	0.0000
	Alcohol - no risk	0.63	0.75	0.0000
	Alcohol - risky behaviour	0.03	0.07	0.0000
Parent death and age of death	Father alive	0.48	0.48	0.9252
	Father deceased - age unknown	0.09	0.09	0.7963
	Father deceased - age $<$ than the ind.	0.31	0.32	0.3497
	Father deceased - age $>$ than the ind.	0.12	0.10	0.0480
	Mother alive	0.64	0.66	0.3611
	Mother deceased - age unknown	0.06	0.06	0.6598
	Mother deceased - age $<$ than the ind.	0.21	0.22	0.6878
	Mother deceased - age $>$ than the ind.	0.08	0.06	0.0028
Number of Observations		1,550	1,306	

Table 2: Summary statistics for SAH, SLE and IUL

	Women	Men	p-value
SAH	72.12	75.85	0.0000
	(21.15)	(18.63)	
SLE	78.79	77.32	0.0002
	(9.72)	(9.66)	
IUL	10.66	10.44	0.3158
	(5.48)	(5.04)	
SLE - Life tables LE	-7.65	-3.49	0.0000
	(9.07)	(8.87)	

Table 3: GLS estimation of the three-equation model, women and men

	Women			Men		
	(1) SAH	(2) SLE	(3) IUL	(1) SAH	(2) SLE	(3) IUL
AGE						
Age	-0.341**	-0.303***	0.067*	-0.431***	-0.114	0.066*
	(0.140)	(0.071)	(0.037)	(0.141)	(0.081)	(0.040)
Age^2	0.003*	0.006***	-0.002***	0.003**	0.004***	-0.002***
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
HEALTH						
SAH	-	0.084***	0.008	-	0.123***	-0.008
		(0.012)	(0.006)		(0.015)	(0.007)
Vital Risks:						
0 illness of type N	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1-2 illnesses of type N	-5.847***	-0.289	0.836**	-3.181***	-0.370	0.059
	(1.396)	(0.669)	(0.346)	(1.098)	(0.593)	(0.293)
$\geq$ 3 illnesses of type N	-10.208***	-0.910	0.745**	-6.762***	-0.770	0.076
	(1.400)	(0.668)	(0.346)	(1.220)	(0.649)	(0.321)
0 illness of type AC	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1 illness of type AC	-7.071***	-1.317**	-0.075	-3.634***	-0.770	0.259
	(1.224)	(0.592)	(0.306)	(1.266)	(0.686)	(0.339)
$\geq$ 2 illnesses of type AC	-7.659***	1.373	-0.169	-5.908**	-1.480	0.310
	(2.535)	(1.212)	(0.627)	(2.338)	(1.268)	(0.627)
0 illness of type A	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
$\geq$ 1 illnesses of type A	-8.246***	-1.260*	-0.180	-9.011***	-2.403***	0.142
	(1.395)	(0.665)	(0.344)	(1.658)	(0.906)	(0.448)
0 illness of type C	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
1 illness of type C	-1.875	-0.862	0.273	-3.931***	-0.054	0.513*
	(1.160)	(0.554)	(0.287)	(1.108)	(0.603)	(0.298)
$\geq$ 2 illnesses of type C	-5.162***	-2.641***	-0.643	-9.037***	-1.907**	-0.480
	(1.669)	(0.797)	(0.412)	(1.528)	(0.841)	(0.416)
Functional Limitations:						
Difficulties to walk: Yes	-4.516***	-	-	-5.688***	-	-
	(1.344)			(1.407)		
Bed-ridden: Yes	-2.252	-	-	-1.294	-	-
	(1.505)			(1.576)		
Difficulties in everyday activities: Yes	-5.786***	-	-	-5.613***	-	-
	(1.489)			(1.553)		
Pain: Yes	-3.591***	-	-	-2.144**	-	-
	(1.180)			(1.080)		
PARENT DEATH AND						

Continued on next page

Table 3 – continued from previous page

	Women			Men		
	(1) SAH	(2) SLE	(3) IUL	(1) SAH	(2) SLE	(3) IUL
AGE OF DEATH						
Father alive	-	Ref.	Ref.	-	Ref.	Ref.
Father deceased - age unknown		0.618	0.526	-	0.141	-0.075
		(1.042)	(0.539)		(1.053)	(0.521)
Father deceased - age < than the ind.	-	-0.620	0.313	-	-0.910	-0.333
		(0.595)	(0.308)		(0.633)	(0.313)
Father deceased - age > than the ind.	-	0.157	0.392	-	-1.237	-0.007
		(0.904)	(0.467)		(1.009)	(0.499)
Mother alive	-	Ref.	Ref.	-	Ref.	Ref.
Mother deceased - age unknown	-	-4.181***	-0.296	-	-3.736***	-0.695
		(1.275)	(0.659)		(1.263)	(0.625)
Mother deceased - age < than the ind.	-	-2.453***	-0.338	-	-1.069	-0.442
		(0.656)	(0.340)		(0.700)	(0.346)
Mother deceased - age > than the ind.	-	-3.121***	-0.113	-	-1.900	-0.272
		(1.014)	(0.524)		(1.180)	(0.584)
LIFESTYLES						
Smoker	-1.872*	-1.924***	-0.102	-3.184***	-2.280***	-0.415*
	(1.034)	(0.494)	(0.256)	(0.897)	(0.489)	(0.242)
Underweight	0.104	-1.144	-0.376	-4.661	1.168	-0.505
	(2.056)	(0.984)	(0.509)	(4.151)	(2.250)	(1.113)
Normal Weight	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight	-2.471**	0.407	0.200	-1.504	-0.260	-0.036
	(1.095)	(0.524)	(0.271)	(0.952)	(0.517)	(0.256)
Obese	-3.378**	1.713**	0.394	-2.707*	0.050	-1.199***
	(1.472)	(0.705)	(0.365)	(1.501)	(0.813)	(0.402)
Severely obese	-9.356***	-0.354	0.190	-8.548***	-0.707	-1.205**
	(1.799)	(0.864)	(0.447)	(1.831)	(1.000)	(0.494)
No Alcohol	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Alcohol - no risk	2.775***	1.220***	-0.210	1.492	1.155**	0.067
	(0.958)	(0.458)	(0.237)	(1.077)	(0.585)	(0.289)
Alcohol - risky behaviour	-1.154	0.566	0.080	-0.446	-2.423**	0.070
	(2.771)	(1.326)	(0.686)	(1.859)	(1.011)	(0.500)
SOCIO-DEMOGRAPHIC						
Education:						
No diploma	-3.564**	-0.546	0.180	-4.067**	-0.619	-0.586
	(1.768)	(0.849)	(0.439)	(1.832)	(0.994)	(0.491)
Primary School certificate	-5.511***	-0.362	0.472	-2.567	-1.566	-0.397
	(1.827)	(0.877)	(0.454)	(1.878)	(1.020)	(0.504)
GCSE	-3.544***	-1.215*	0.979***	-1.506	-2.509***	-0.694**
	(1.338)	(0.641)	(0.332)	(1.223)	(0.663)	(0.328)
Baccalauréat	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
University (≤ 2 years)	-0.568	0.928	1.098***	0.642	-1.514*	-0.728*
	(1.605)	(0.768)	(0.397)	(1.610)	(0.871)	(0.431)
University (≥ 3 years)	-2.804*	0.958	0.430	0.683	-0.314	0.098
	(1.645)	(0.787)	(0.407)	(1.484)	(0.801)	(0.396)
Other diploma	-29.778**	-3.531	0.728	-13.350	2.933	1.408
	(13.453)	(6.442)	(3.333)	(8.157)	(4.420)	(2.186)
Income:						

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Table 3 – continued from previous page

	Women			Men		
	(1) SAH	(2) SLE	(3) IUL	(1) SAH	(2) SLE	(3) IUL
Income ≤ 875 €	-3.494***	-1.196*	-0.168	-1.961	-0.796	-1.311***
	(1.354)	(0.650)	(0.336)	(1.287)	(0.698)	(0.345)
Income ∈ [875 − 1290] €	-3.266***	-0.429	0.069	-0.770	-0.005	-0.602*
	(1.249)	(0.599)	(0.310)	(1.163)	(0.629)	(0.311)
Income ∈ [1290 − 1800] €	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Income > 1800 €	-0.914	-0.059	-0.278	0.390	-1.204*	-0.484
	(1.314)	(0.630)	(0.326)	(1.141)	(0.619)	(0.306)
Health Insurance:						
National Health Ins. only	-1.572	-0.872	0.891*	-2.852*	1.004	-0.033
	(2.123)	(1.015)	(0.525)	(1.615)	(0.878)	(0.434)
CMUC only	1.381	-0.372	0.446	-6.394***	-3.699***	0.042
	(1.949)	(0.927)	(0.480)	(2.139)	(1.163)	(0.575)
Complementary Insurance	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Family Situation :						
Marital life	0.569	0.705	0.457*	1.448	-0.127	0.048
	(1.008)	(0.481)	(0.249)	(1.002)	(0.543)	(0.269)
Single	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
At least one child	0.628	-0.114	-0.178	1.132	-0.641	-0.144
	(1.024)	(0.492)	(0.255)	(1.043)	(0.567)	(0.281)
No Child	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Constant	101.059***	74.896***	12.001***	100.530***	67.501***	15.215***
	(3.495)	(2.124)	(1.099)	(3.326)	(2.368)	(1.171)
$\rho_{1,2}$		-0.0021			0.0075	
$\rho_{1,3}$		-0.0136			-0.0107	
$\rho_{2,3}$		-0.2745***			-0.1794***	
R2	0.360	0.315	0.440	0.359	0.341	0.405
St. Dev of Dependent Variable	20.09	9.32	4.84	22.08	9.43	5.34
RMSE	16.79	8.02	3.95	18.28	8.13	4.17
N		1501			1290	

Table 4: GLS estimation of the three equation model for smokers only

	Women			Men		
	(1) SAH	(2) SLE	(3) IUL	(1) SAH	(2) SLE	(3) IUL
PARENT DEATH AND AGE OF DEATH						
Father alive	-	Ref.	Ref.	-	Ref.	Ref.
Father deceased - age unknown		-0.552	-0.442	-	-2.972*	0.187
		(1.836)	(0.862)		(1.574)	(0.718)
Father deceased - age < than the ind.	-	-1.445	0.084	-	-2.175**	-0.110
		(1.060)	(0.498)		(1.048)	(0.478)
Father deceased - age > than the ind.	-	2.828	0.567	-	-3.213**	0.570
		(2.003)	(0.940)		(1.617)	(0.738)
Mother alive	-	Ref.	Ref.	-	Ref.	Ref.
Mother deceased - age unknown	-	-6.345***	0.470	-	-3.205	-0.770
		(2.663)	(1.250)		(1.965)	(0.896)
Mother deceased - age < than the ind.	-	-4.769***	-1.162	-	-1.779	-0.189
		(1.272)	(0.597)		(1.083)	(0.494)
Mother deceased - age > than the ind.	-	-5.962*	-1.463	-	-3.645*	0.445
		(3.154)	(1.480)		(2.000)	(0.913)
All other variables from table 3 also included						
N		511			488	

7 Appendix

Figure A.1: Vital risk by age for men and women

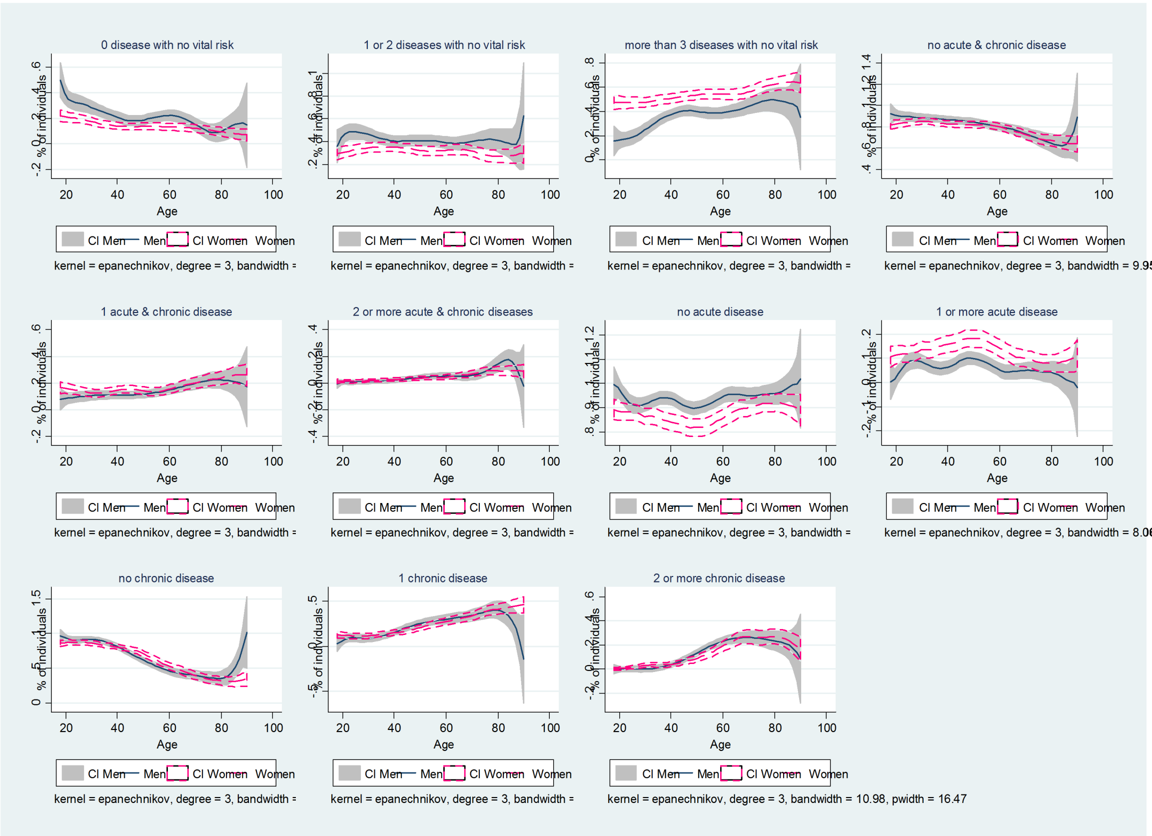

Figure A.2: Proportion of smokers by age and gender

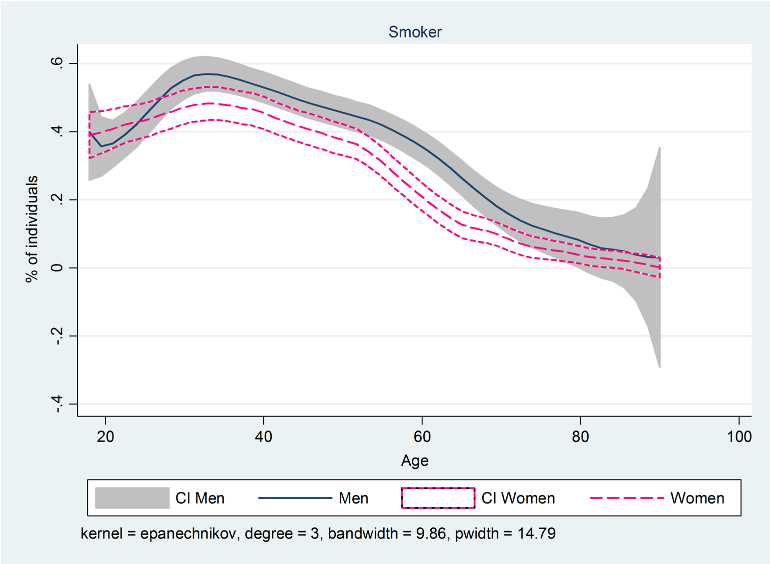

Figure A.3: BMI and obesity problems by age for men and women

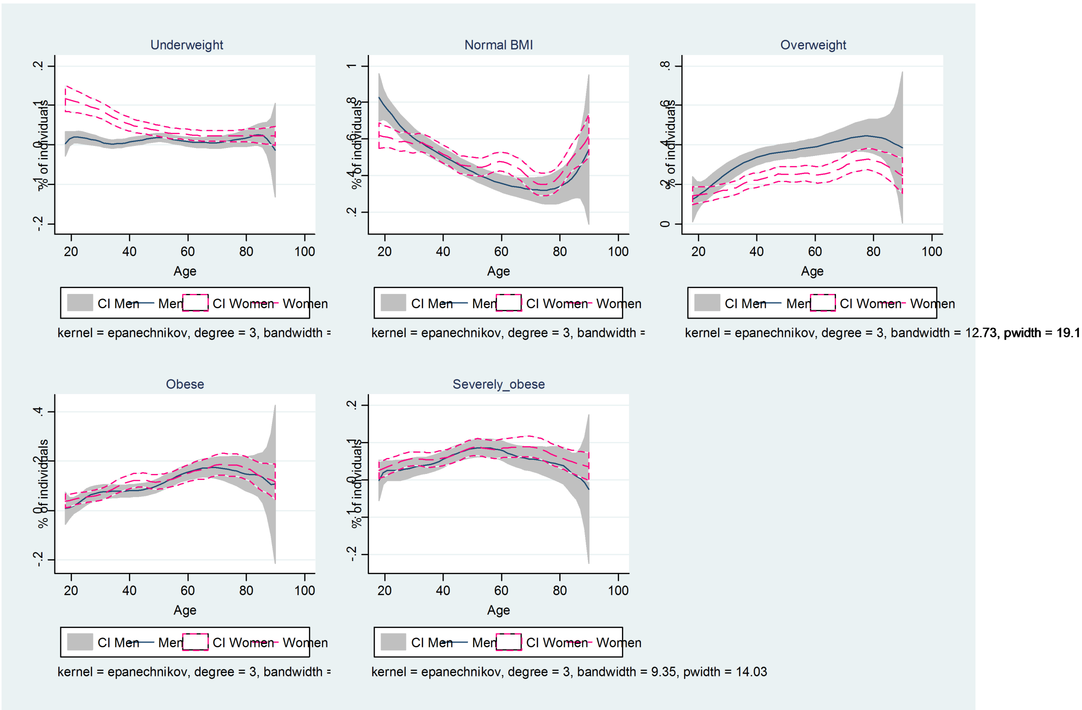

Figure A.4: Alcohol consumption by age for men and women

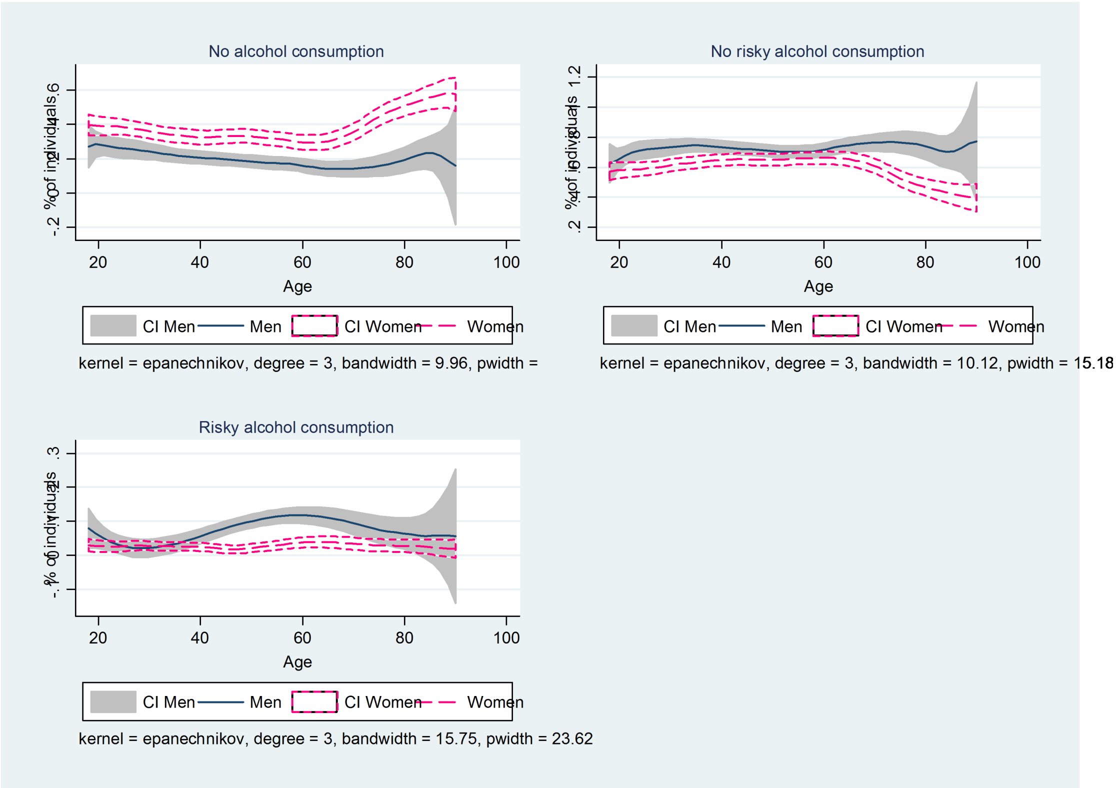

Table A.1: TO BE ADDED

	Women	Men
Age	-0.415**	-0.403**
	(-2.64)	(-2.61)
Age^2	0.00337*	0.00317*
	(2.06)	(2.10)
1-2 illnesses of type N	-5.190***	-2.723*
	(-3.75)	(-2.34)
$\geq$ 3 illnesses of type N	-9.460***	-5.541***
	(-6.75)	(-4.28)
1 illness of type AC	-6.739***	-3.413**
	(-5.41)	(-2.65)
$\geq$ 2 illnesses of type AC	-8.425**	-5.318*
	(-3.16)	(-2.27)
$\geq$ 1 illnesses of type A	-8.483***	-9.882***
	(-6.02)	(-5.68)
1 illness of type C	-2.279	-4.003***
	(-1.89)	(-3.52)
$\geq$ 2 illnesses of type C	-5.278**	-9.238***
	(-3.02)	(-6.08)
Difficulties to walk	-4.145**	-5.923***
	(-2.98)	(-4.16)
Bed-ridden	-1.593	-1.798
	(-1.02)	(-1.05)
Difficulties in everyday activities	-6.621***	-5.939***
	(-4.26)	(-3.68)
Pain	-3.296**	-2.029
	(-2.72)	(-1.79)
Smoker	-2.539*	-2.821**
	(-2.44)	(-2.92)
Underweight	-1.289	-12.88**
	(-0.63)	(-3.11)
Overweight	-2.815*	-1.155
	(-2.52)	(-1.15)
Obese	-3.648*	-2.358
	(-2.36)	(-1.53)
Severely_obese	-9.505***	-8.302***
	(-5.17)	(-4.29)
Alcohol - no risk	2.892**	1.614
	(2.98)	(1.39)
Alcohol - risky behaviour	-0.896	-0.317
	(-0.33)	(-0.17)
No diploma	-3.588*	-2.265
	(-1.96)	(-1.14)
Primary School certificate	-5.005**	-1.705
	(-2.60)	(-0.90)
GCSE	-3.246*	-0.509
	(-2.41)	(-0.39)
University $\leq$ 2 years	-0.558	2.057
	(-0.35)	(1.19)
University $\geq$ 3 years	-2.219	0.931
	(-1.38)	(0.59)
Other diploma	-29.72	-11.00
	(-1.95)	(-1.09)
Income $<$ 875 €	-4.303**	-2.658
	(-3.13)	(-1.96)

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	Women	Men
Income $\in [875 - 1290]$	-3.206*	-1.350
	(-2.51)	(-1.08)
Income $>$ 1800 €	-0.899	0.149
	(-0.69)	(0.13)
National Health Ins. only	-0.536	-2.618
	(-0.26)	(-1.52)
CMUC	3.030	-5.577*
	(1.52)	(-2.36)
Marital Life	-0.167	1.893
	(-0.16)	(1.80)
Child	1.115	1.320
	(1.07)	(1.21)
Father deceased - age unknown	0.519	-0.791
	(0.24)	(-0.39)
Father deceased - age $>$ than the ind.	-0.412	-1.662
	(-0.20)	(-0.88)
Father deceased - age $<$ than the ind.	1.751	0.743
	(1.39)	(0.59)
Mother deceased - age unknown	-0.896	-0.505
	(-0.33)	(-0.22)
Mother deceased - age $>$ than the ind.	-0.352	-2.518
	(-0.16)	(-1.18)
Mother deceased - age $<$ than the ind.	-0.564	-2.631
	(-0.39)	(-1.96)
Constant	101.8***	97.58***
	(27.68)	(26.78)
N	1550	1306
Fisher stat. (Weak Instruments)	21.40	17.01
Sargan stat	4.482	4.385
(p-value)	0.214	0.223
Hausman stat (SLE)	0.57	1.18
(p-value)	0.45	0.28
Hausman stat (IUL)	4.31	3.61
(p-value)	0.04	0.06