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GREQAM

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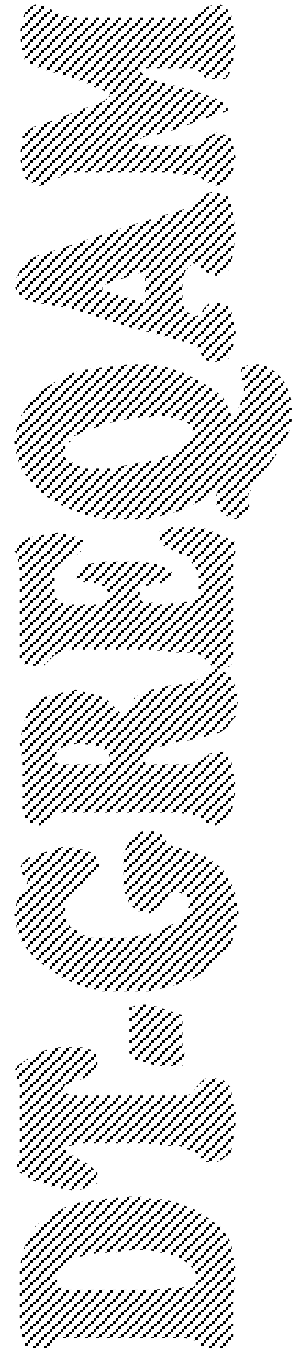
Healthy Aging *versus* Demographic Trends: the French Case, Estimated by Markovian Microsimulation Methods

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Abstract: The Objective of this paper is to test the consequences of changes in health status of future cohorts of French elderly on healthcare expenditures. We value the precise effect of epidemiological and life expectancy changes on health expenditures for 2025 by using a markovian microsimulation model for a representative database of the contemporary cohorts in France. The originality of these simulations holds in the use of an aggregate indicator of morbidity-mortality, capturing a vital risk and making possible to adapt the quantification of the life expectancies by taking into account of a life without incapacity and/or of the presence of severe pathologies. We forecast a reliable range for future national health spending, under different epidemiological scenarios of morbidity: benchmark case (BM), healthy aging (HA), healthy aging and medical progress (AM). We obtain an evaluation of the annual growth rates in health expenditure accounted for solely by aging: +1.18%; +0.95%; +1.38% according to the scenarios BM; HA; AM. In short, the effective decreases in morbidity rates are not sufficient enough to compensate the massive arrival of baby-boomers at elderly age in France for the period 2010- 2025.

Introduction

The factors explaining the increase in health expenditure are generally divided into two types: demographic factors (aging of the population, lengthening of the lifespan and epidemiologic changes) (Bebbington et Shapiro, 2005) and non-demographic factors (income elasticity, price elasticity, technology and medical practices) (see Dormont, Grignon et al., 2006 for a comprehensive decomposition of these effects for France, see also EC-EconomicPolicyCommittee, 2005; EC-EconomicPolicyCommittee, 2006; OECD, 2006). Macroeconomic projections of health expenditures insist on sensitivity of their results to epidemiologic evolutions (Oliveira Martins et De la Maisonneuve 2006), but can take them into account only by making *ad hoc* assumptions on these evolutions and by sacrificing microeconomic dimension. In the context of population aging, the stake is to determine the future prevalence ("stocks") of chronic diseases (Verbrugge et Jette, 1994). If one wants to be rigorous, simulation of epidemiologic changes must be realized through assumptions on incidence rates ("flows"). In this paper we make it possible to carry out prevalence projections from a set of formulated on incidence to get the precise effect of epidemiological and life expectancy changes on health expenditures for 2025 by using a microsimulation model. Such simulations are impossible using a "macro" method. Macrosimulation relies on modifying the weights of the sick and non-sick populations via *ad hoc* assumptions about future prevalence rates, which inevitably decide the aggregate consequences of the scenarios (VanImhoff et Post, 1997).

Internationally, some efforts were carried out, operating this new applied modeling method in the field of health (Marquis et Long, 1997; Zabinski, Selden et al., 1999; Gruber, 2000), the technique itself borrowed from tax analysis (Citro et Hanushek, 1991; Mot, 1992). But few models were interested in a macroeconomic diagnosis of health expenditure and its evolution at a far horizon (2025). The work of Rand Corporation (which is similar to our model) concerns the particular population of 65-plus people eligible to the Medicare program in the United States. Characteristics of the US population -particularly that of Medicare- require taking into account specific scenarios from the French case in particular because of the bad health of the new American cohorts (e.g. the obesity and diabetes epidemic) (Goldman, Shang et al., 2005). Another example is the paper of Dormont, Grignon et al., 2006 which breaks up perfectly the effects "morbidity shift" and "seeking care intensity", but on retrospective data not yet integrating the epidemiologic change assumptions of width advanced for example by Michel et Robine, 2004 for the future generations of sixty-plus.

The originality of these simulations holds in the use of an aggregate indicator of morbidity-mortality, capturing a vital risk and making possible to adapt the quantification of the life expectancies by taking into account of a life without incapacity and/or of the presence of severe pathologies. Breyer et Felder, 2006 showed that models integrating a better predictor of healthcare needs than chronological age (they used a "time to death index") gives more precise estimates while measuring the effect of aging on health expenditures. As well, Shang et Goldman, 2008 showed that life expectancy has a bigger predictive power than chronological age but diminishes while introducing health indicator. They also have shown that this drives to a lower projection of future health expenditures. In the context of healthy aging, these findings suggests that introducing health status and life expectancy into the model of spending may lead to a lower estimate than when using chronological age only. Then using this index drives to get a more precise prediction model.

Methods

Databases

Two databases were used to perform the simulations. Participant data from the administrative set of data the Public Insured Permanent Sample (EPAS) and the Health and Social Protection Survey (ESPS2000) were united to form a single database. Social security numbers were used to match respondents across datasets. The EPAS exhaustively details all health reimbursed expenditure made by members of the National Insurance. A major advantage of the EPAS is that it contains exact expenditure data, which circumvents the inconsistencies generated in self-report questionnaires. A limitation is that ambulatory (i.e. non hospital) expenditure data are complete, whereas the hospital data could miss –because they are not gathered individually, but as a "collective spending" (public good). Consequently, only ambulatory care expenditure data were used in this study. In Metropolitan France, ESPS data has been collected via self-administered questionnaires every two years since 1988, by the IRDES/CREDES. It comprises a nationally representative sample of 22,000 National Insurance Scheme members from 8,000 households. The major advantage of this database within the current study framework is that it contains a wealth of additional information complementary to the EPAS, including individual and household demographic characteristics, epidemiologic data including several synthetic indicators of health conditions and socio-economic data. United, the ESPS and EPAS provide the most accurate, comprehensive, and representative health expenditure and social health data on the French population. The combined database comprised 5,944 observations, weighted to represent the total metropolitan population.

Morbidity- Mortality Index: Taking into account "Time to Death"
The Morbidity-Mortality Index is built from two health-related indexes found in the ESPS2000 data base: a vital risk and a disability index, both rated by medical doctors on the basis of the individuals' interview (by telephone and by self-questionnaire, reporting all past and present diseases of agents). Vital risk corresponds to the death likelihood level and is rated on a 6-point Likert scale (Likert, 1932) from "no essential risk" to "a definite poor prognosis" and defined as an 80% probability of death within five years. The disability index captures the disability level induced by chronic conditions and is rated on an 8-point Likert scale from "no impairment" to "permanently bed-ridden" (Perronnin, Rochaix et al., 2006). We decided to also use this latter index in order to increase the significance of our final indicator in the econometric model (people with disability are great consumer of health care even when vital risk is low). From both variables, we created an aggregate indicator (see appendix A). This morbidity/mortality index gives aggregate information of the diseases and the life expectancy of the individual at the time of the survey. It makes possible to predict the future expenditure by getting a foreseeable individual epidemiologic dynamics on this aggregate indicator with no need for a projection of the whole diseases range.

Aging process: Markovian methods

First future individual's health status is forecasted using a microsimualtion model according to the following: From time t, an individual is either in good health, or bad health, or dead; at the next time,

in t+1 (one period lasts 5 years), the same person's health is determined by a transition rates matrix according to his last health status. The transition rates matrixes contain probabilities of transition from a given health status towards another. We consider a matrix by age group (5 year age brackets) and by gender

$$\vec{\varepsilon}_{n,T+5} = \vec{\varepsilon}_{n,T} \begin{pmatrix} \dots & P_{i/j} & \dots \end{pmatrix}$$ where $\varepsilon_{n,T}$ is the health status of person n at time T and $P_{i/j}$ the

transition probability between state i and j.

$$\tilde{C}_{n,T+5} = \vec{\varepsilon}_{n,T+5} C_n = \vec{\varepsilon}_{n,T} \begin{pmatrix} \dots & P_{i/j} & \dots \end{pmatrix} C_n$$ where C_n is the cost vector of representative individual

n given by the two-part econometric model.

Transition rates are estimated from cross sectional data in 2004. The transitions are computed for each age group and each gender. They are then modified by shifting the transition probabilities to obtain the scenarios. The model does not take into account any assumption of immigration; the population studied for 2025 is exactly the same one as in 2000, less dead people.

In the "Benchmark" Scenario (BM) the risk of falling sick is held constant. The matrixes of the BM case refer to the current morbidity and mortality rates. The former are directly induced from a cross-sectional use of the database and the latter are given by the mortality tables adjusted by age and the year of birth. Thus, after simulations of health status and consecutive expenditures, we will obtain the amount of the expenditure rise related to the demographic effects only. Differences in expenditures come only from changes in the population pyramid (the "grandpa boom", with larger population sizes for the older age brackets).

In the "Healthy Aging" Scenario (HA) the incidence is modified: morbidity rates decrease, "relative" life expectancy remains constant. To obtain the matrixes of this scenario the probabilities "from good health to good health" are shifted two age brackets for men and one age bracket for women. So the share of healthy days and unhealthy lifespan is changed in the total lifespan. It is a scenario of "Healthy Aging" in the sense that days in good health will increase in the total life-time of future aged individuals *without direct changes of lifespan (i.e.* without direct change in death rates). But there is an indirect effect of increase in lifespan while only the probabilities of becoming sick are changed: less people die because healthy people death rates are lower than for sick people. This translated the theory of Robine, 2007 on aging and the rectangularization of the survival curve.

In the "Advance in Medicine" Scenario (AM) technology is assumed to reduce the death rates of unhealthy people (by the transformation of fatal diseases into chronic diseases), and to keep people healthy and alive for longer. The matrixes of the "Advance in Medicine" scenario are thus the result of a shift of all probabilities (two age brackets for men and one age bracket for women, as before).

In this paper, the effects of medical progress are simulated in terms of demographic consequences only. We did not include a scenario of changing cost. The issue of the evolution of the price index for

healthcare is a complex one, particularly given the myriad ways in which medical progress may occur. Broadly speaking, productivity gains due to technology generally reduce the relative price of healthcare, while costs associated with the development and implementation of new technology generally raise it. In the current study, we have chosen to make the conservative assumption that the price index of healthcare remains constant in real terms - it evolves at the same rate as the GDP price index. The demographic effects of (healthy) aging are modelled "all other things being equal".

Acute Care Expenditures Forecasting Model

We used a micro-econometric model to forecast health expenditures for each individual. As noticed earlier the administrative data exhaustively recorded ambulatory expenditures only. These expenditures include spending occurring outside hospital such as practitioner visits and cares, biological tests, pharmaceutical products, medical equipments, optical care and products (glasses), prosthesis and orthotics.

A sequential "two-part" econometric model (Manning, Morris et al., 1981) was chosen over three alternatives commonly used to model health care expenditures (see Jones, 2000; Deb et Trivedi, 2006 for a review of these models). In the French system, the family physician is the gatekeeper to whom a citizen must present to obtain health care. The physician then decides how much the system will spend on the patient by allocating health care resources including drug prescriptions and by orienting them towards relevant health services. This sequential two-part process is best captured by the two-part model. The first part of the model, the probability to seek care, was estimated through a Logit model. The log-transformed level of expenditure (which addressed the skew problem) was then estimated with an OLS model using one smearing factor to correct for heteroskedasticity (see Buntin et Zaslavsky, 2004 for a detailed explanation about the way to choose a particular technique to forecast health expenditures).
As shown in table 1, health status was the strongest predictor of care seeking behavior, followed by age, gender, and private health insurance. The ill, elderly, women, and privately insured were the most likely to engage with the health system. Similar trends were observed for expenditure.

Results

Projected demographic structures

The population pyramids in Figure 1 illustrate the effects of the simulated epidemiologic changes on the demographic structure of the population. These pyramids are first characterized by their tops, that is to say, by the demographic structure of the elderly populations. The pyramid relating to scenario BM shows the trends prolongation of current population (aged baby boomer). The median part of pyramid ESPS2000 is found quasi mechanically at the top of pyramid BM. A generational imbalance is apparent, with decreasing number of young compared to the 60-plus. Moreover, the joint effect of baby-boom and lifespan lengthening results in a sizeable enlargement of the 90-plus population. Under the scenario of "healthy aging", 60 plus people are more numerous than in BM.

This is due to the second order effect; the fall of morbidity involves a fall of mortality (Cf scenarios description).

The "advance in medicine" scenario results in an even stronger difference from the BM, with a consequent widening of the pyramid top. It is the expression of the first order effect of mortality fall among the oldest age groups. This extreme case shows the risk of a total upheaval of the relationship between the potential numbers of workers and retirees (EC-EconomicPolicyCommittee, 2001).

Table 2 shows an increase of the 60-plus, from 28% to at least 43% (among the 25-plus) between 2000 and 2025 in the most favorable case. When compared to the tendency prolongation scenario (BM), the healthy aging scenario will potentially reduce the share of unhealthy people among the older (60 plus) population by 5.87 percent. Under the AM scenario, the numbers of unhealthy and healthy people are respectively 30% and 10% superior to the BM scenario.

Analyses of projected health expenditure

The econometric model integrates age under three dimensions, which confers its particular empirical form on the expenditure profile, initially increasing then decreasing as survivors move into the highest age groups (Figure 2). This translates the effect of catastrophic expenditure (proximity to death), which is high for old persons but which tends, however, to be relatively less important when people reach an age beyond 90 years (with probably a weaker technico-medical investment to keep these people alive, see Shoven, 2004 for an equivalent effect). Thus, population aging consequences on health expenditure depend on a subtle balance between population repartition across age groups and the epidemiologic evolutions. Note that the chronological variable of age thus remains determinant of expenditure level; perhaps capturing the marked increase in health prevention behaviors practiced by aged-populations, whatever their health status.

At the turn of the millennium in France, expenditure distribution across age groups was rather uniform. However, the three projections in this study estimate a net imbalance in 2025. Longer lifespan will see the volume of expenditure accounted for by the 60-plus population increase considerably. This rise is directly related to the increasing number of people in these older age groups. Comparisons of expenditure between the various scenarios of aging suggest that `healthy aging' scenario results in a light profit (5% on average) compared to the BM. The graphs of scenarios BM and HA are very close; the variation is really visible only for the higher age groups (after 60 years). Taken together, the results suggest that it is the number of elderly persons which determine the amount of expenditure, rather than their distribution between healthy and unhealthy states. The effect of an increase in life expectancy (scenario AM) on expenditure is more strongly inflationary. A longer living population means that both the number of healthy people and unhealthy people increase. The groups aged 75-plus will place the greatest pressure on health expenditure, since this is where the population is projected to experience the greatest growth (cf population pyramid).

Table 3 highlights the impact of the projected aged population increase, in terms of expenditure distribution between healthy and unhealthy persons, and the share devoted to the 60 plus population. On the whole, the pure effect of the aging French population is likely to generate an increase in expenditure of 34% (comparison 2000/BM for 25 plus people). Under scenario BM, population aging contributes to a rise of 1.18% to the annual expenditure growth rate. Under the healthy aging scenario, a rise of 26.7% or 0.95% annually is projected.

Discussion

The model is able to forecast a reliable range for future national health spending, under different epidemiological scenarios for disability (benchmark case, healthy aging, healthy aging and medical progress). These scenarios are mainly based on the theories of aging of Robine et Michel, 2004 and allow to quantify precisely the future effect on health expenditure of various epidemiologic alternatives. This work thus rests on a double approach, both epidemiologic and economic (a "disease oriented model" according to Jacobzone, 1999). The first scenario, BM, forecasts health expenditure arising in a future in which actual health trends continue 25 years into the future (Bebbington et Shapiro, 2005). The second, HA, simulates a scenario of 'healthy aging' or reduced morbidity, brought about by a reduction of the risk to become chronically ill, in which the probabilities of falling sick are simulated to be smaller than those currently observed. This scenario actually leads to a "natural" lifespan lengthening: the population is less likely to have chronic condition so the average lifespan is increased. In the third one, called AM "advance in medicine", we add an increase in life expectancy to the healthy aging.

Simulations results show that "healthy aging" is not sufficient to attenuate the flow of expenditures created by population aging. The principal element of the explanation is that, as showed by results, health consumption is strongly increasing with age, whether people are unhealthy or otherwise. If mortality rates decrease due to medical innovations (AM), the number of chronically ill survivors increases as does the number of healthy people aged 60-plus. Healthy aging consequently counterbalances even less the expenses flow generated by population aging. Results give a precise evaluation of the annual growth rates in health expenditure accounted for solely by aging: +1.18%; +0.95%; +1.38% according to the scenarios BM; HA; AM, which is a little higher than the evaluation given by a study on French retrospective data: +0.8% Azizi et Pereira, 2005. However they studied the period 1970-2002 and insist on the fact that this rate will increase in the future. One can fear a situation more alarming for expenditure in long term care (nursing homes, supporting disabled elderly) (Norton, 2000), because the figures presented here relate only to ambulatory expenditures. Indeed, expenditures on care for the elderly includes spending in domestic care (either not recorded or badly taken into account by the "health accounts") and in long hospital stays. One could thus expect rises in long term care expenditure proportionally greater than the ambulatory sector. By simulating ambulatory expenditure only, we undoubtedly minimize the impact of aging, even by considering only the growth rates.

In spite of an individual risk reduced to be sick, the growth of elderly populations under the effect of the demographic trends prevailing in France, lead to an important increase in the number of sick people - purely mechanical effect. Moreover individuals in good health are more numerous and, in spite of their good health status, their consumption is non zero and also increases with age. The solutions for France to deal with its aging concern is not necessarily to decrease the care given to the chronically ill, but maybe to make the healthy population think differently about the way they consume healthcare (consumerism). However, the added effect of this consumerism on healthy aging is not known. One could imagine that it is an investment in human health capital and would lead to a "healthier" population, maybe less expensive to take in charge when experiencing tangible bad health and time-to-death period.

Tableau 1: Probability to seek care and level of expenditure (two part model estimation on full sample)

	Two Part Model	
	Pr(Seek Care)	Log (expenditure)
Intercept	1. 82***	6. 44***
Good Health	- 0. 24***	- 0. 74***
Age	- 0. 20***	$- 1.26 \cdot 10^{-2}$**
Age²	0. 003**	$7.85 \cdot 10^{-4}$***
Age³	$- 10^{-5}$*	$- 5.50 \cdot 10^{-6}$***
Male	- 0. 18***	- 0. 32***
No Private Health Insurance	- 0. 12*	- 0. 07*

*Significant at 10%; **significant at 5%; ***significant at 1%.

Tableau 2: 25+ population distribution according to scenarios

	ESPS2000	BM	HA	AM
Unhealthy people	29. 35 %	37. 26 %	30. 84 %	34. 78 %
60+ among the 25+	28. 10 %	42. 94 %	45. 26 %	48. 10 %
Unhealthy people among the 60+	56. 49 %	57. 73 %	47. 81 %	53. 68 %
TOTAL 25+ Population in Million	41. 45	46. 19	46. 73	49. 55
TOTAL 60+ Population in Million	11. 64	19. 84	20. 37	23. 02

Tableau 3: Health expenditures in 2025 compare to 2000

	ESPS2000	BM	HA	AM
25+ acute care spending	47.0 Billion Euros	+33.94 %	+26.68 %	+40.90 %
Unhealthy 25+ spending	25.5 Billion Euros	+53.51 %	+20.50 %	+46.71 %
60+ spendings	24.5 Billion Euros	+63.62 %	+53.42 %	+79.59%
Unhealthy 60+ spendings	18.0 Billion Euros	+67.20 %	+30.28 %	+65.82%

Figure 1: Age pyramids according to scenarios

ESPS 2000

Benchmark Case 2025
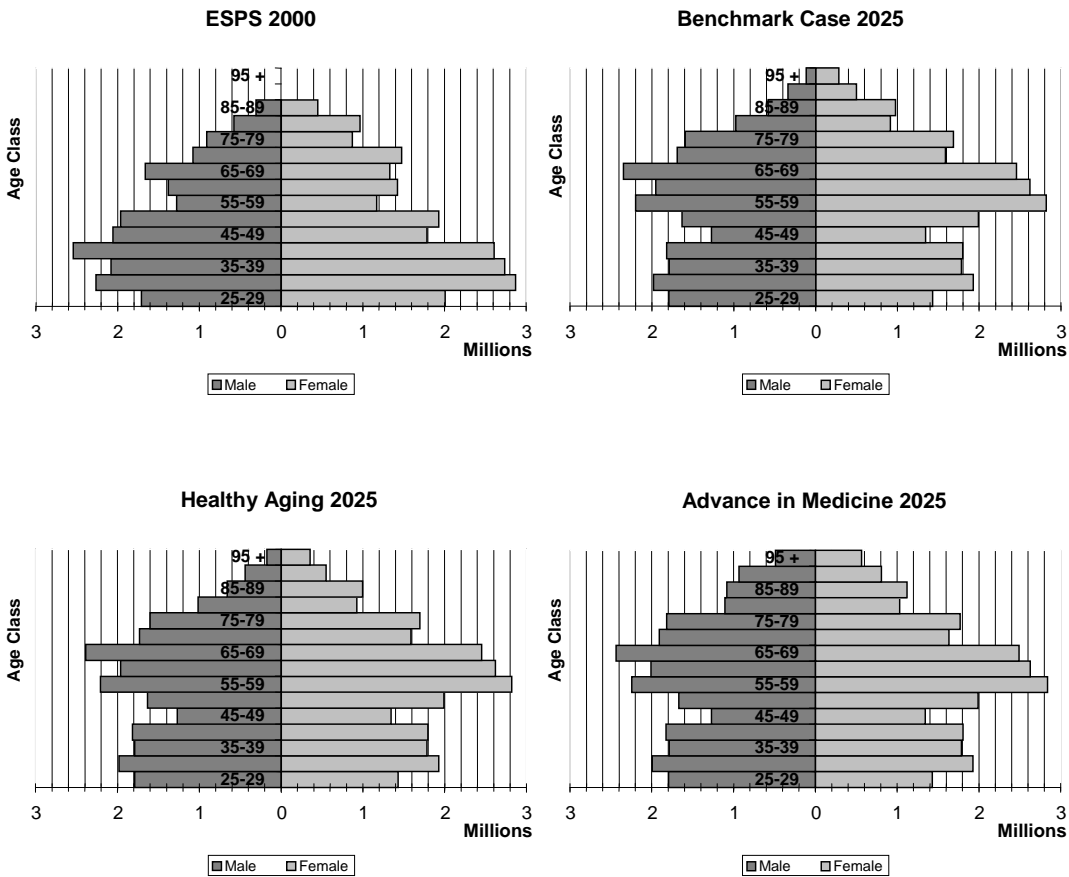
Healthy Aging 2025

Advance in Medicine 2025

Figure 2: Predicted effect, by the econometric model, of age on health expenditure after taking health status into account
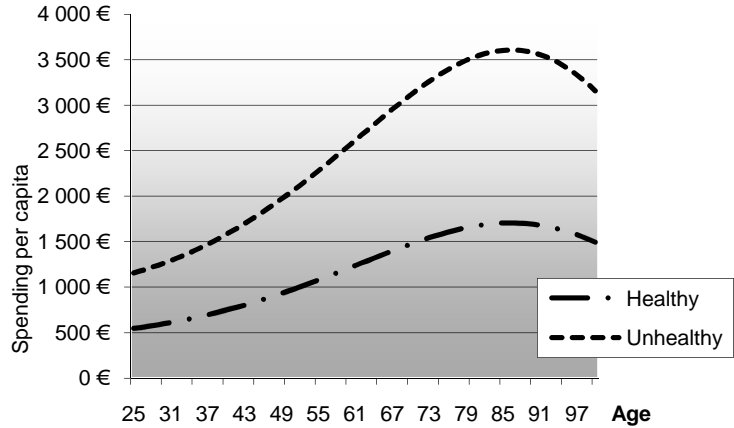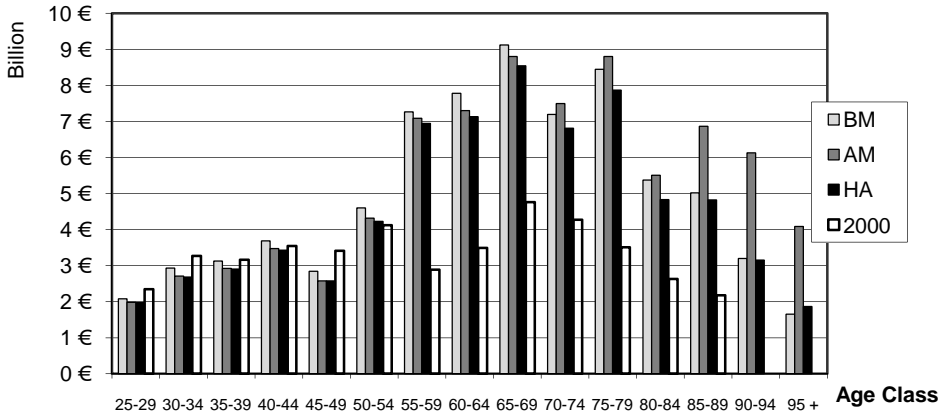
Figure 3: Health care spending according to age groups and scenarios

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Appendix A: morbidity-mortality index

Disability	Vital Risk	0: No Vital Risk	1: Very Low	2: Low	3: Possible Vital Risk	4: Poor Prognosis	5: Very Poor Prognosis	Total
0 : **No Disability**		16,24%	1,71%	0,74%	0,09%	0,00%	0,00%	**18,77%**
1 : **Minimal Disability**		8,66%	3,31 %	1,84%	0,42%	0,00%	0,00%	**14,23%**
2 : **Few Disability**		7,87%	5,25%	13,77%	1,88%	0,00%	0,00%	**28,77%**
3 : **Disability, but Normal Living**		2,30%	2,16%	13,36%	5,16%	0,31%	0,00%	**23,29%**
4: **Have to Decrease Professional and Household Activities**		0,31%	0,44%	2,99%	5,31%	2,36%	0,14%	**11,54%**
5 : **Low Autonomy**		0,04%	0,04%	0,17%	0,78%	1,48%	0,32%	**2,83%**
6 : **No Household Autonomy**		0,00%	0,03%	0,00%	0,09%	0,16%	0,21%	**0,49%**
7: **Full time Confinement to Bed**		0,00%	0,00%	0,00%	0,02%	0,06%	0,00%	**0,08%**
Total		**35,42%**	**12,94%**	**32,86%**	**13,75%**	**4,37%**	**0,67%**	**100%**

The "healthy" status is defined by the lighter part of the table above.