Demographic Uncertainty and Health Care Expenditure in Spain*

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Abstract:

Usual projections of health care expenditure combine age-sex profiles of health expenditure and scenarios of population projection. However, it has been shown repeatedly that both age-sex specific health expenditures and the population structures in the future are highly uncertain and most projections turned out wrong. Therefore, the projections based on the traditional approach are often unhelpful in evaluating future health care expenditures. In this project we try to improve upon the existing literature by incorporating uncertainties in population projection and future age-sex specific health expenditure. Combining the stochastic population projection with age-specific health expenditure we obtain probabilistic distributions of health expenditure. The median projection shows that public health expenditure will increase by about 40% during the next 47 years, that is, an average annual increase of 0.74%. There is a 10% chance that the expenditure will increase by more than 66% during the projection period, which corresponds to an annual increase of 1.1%. At the optimistic side the total public health expenditure will grow only by 17% (0.35% annual) with a 10% probability. The main part of the increase in total expenditure is driven by the increase in average per-capita expenditure due to ageing. The average per-capita expenditure increases by 33%, from 980 in 2004 to 1307 euros in 2050. If we assume that real per-capita public health expenditure increases by the same rate as per-capita GDP, the share of the public health expenditure in GDP will increase from 5% today to 6.7% in 2050, solely due to demographic change. One factor that could reduce the expenditure pressure in the future is that with decreasing mortality rate there will be fewer people in their last year of life. This, combined with the fact that a major part of health expenditure is driven by decedents, could reduce future health expenditure. Our estimation suggests that distinguishing hospital costs by survival status could reduce somewhat (by about 8%) total hospital expenditure in 2049.

Resumen:

Las proyecciones habituales del gasto en cuidados médicos combinan perfiles del gasto en salud por edad y sexo y distintos escenarios de evolución de la población. Sin embargo, se ha mostrado repetidamente que los gastos específicos en salud por edad y sexo y las estructuras de la población en el futuro presentan una gran incertidumbre, por lo que la mayoría de las proyecciones resultan incorrectas. Por lo tanto, las proyecciones realizadas mediante métodos tradicionales no son válidas para evaluar el gasto sanitario futuro. En este proyecto pretendemos realizar una aportación a la literatura incorporando incertidumbre en las proyecciones de población y en el gasto futuro en salud por edad y sexo. Combinando la proyección estocástica de la población con un gasto sanitario específico por edad obtenemos distribuciones probabilísticas del gasto futuro en salud. La proyección mediana muestra que el gasto sanitario público aumentará en torno a un 40% durante los próximos 47 años, es decir, un incremento medio anual del 0.74%. Con una probabilidad del 10%, el gasto aumentará en más de un 66% durante el período de la proyección, lo que se corresponde con un aumento anual de 1.1%. Por el contrario, en un escenario optimista el gasto sanitario público total crecerá solamente un 17%, i. e., un 0.35% anual, con una probabilidad del 10%. La causa principal del aumento en el gasto total es el incremento en el gasto medio *per capita* derivado del proceso de envejecimiento. El gasto medio *per capita* aumenta un 33%, desde 980 euros en 2004 a 1307 euros en 2050. Si asumimos que el gasto sanitario público per capita aumenta a la misma tasa que el PIB *per capita*, la participación del gasto sanitario público en el PIB pasará de un 5% en 2004 a un 6.7% en 2050, solamente debido al cambio demográfico. Un factor que podría reducir la presión del gasto en el futuro sería la disminución de la tasa de la mortalidad dado que una parte importante del gasto sanitario es causada por el fallecimiento. Nuestra estimación sugiere que diferenciar el coste hospitalario según la supervivencia del paciente reduce ligeramente (cerca del 8%) la magnitud estimada del gasto hospitalario total en 2049.

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1. Introduction

Population aging will be one of the most important social phenomena of the twenty-first century. It is important because eligi bility for most major social transfer programs are strongly tied to age and so are affected by changes in population age structures, which is also true with the government revenues from which these social programs are financed. One of the areas where aging will be particularly relevant is health care expenditure. National health expenditure already takes a substantial share of GDP in most developed countries, ranging from 7 percent in Spain and 14 percent in the US. Furthermore, during the last decades national health expenditure as a proportion of GDP has increased in most developed countries.

One obvious link between population aging and national health expenditure is due to the fact that per-capita health spending increases with age. Estimated ratios of per-capita health spending between the population aged 65 and over and the population under 65 years range between 2.5 to 5 in developed countries (see, for example, Anderson and Hussey, 2000). There are also large differences in health spending by age among the elderly population. For example, Fuchs (1998) estimated that per-capita health expenditure among the oldest-old (85 years and above) were three times that for those in ages 65-75, and twice that for those in ages 75-84. On-going population aging in the developed countries leads not only to an increasing proportion of the elderly population but also to an increasing proportion of the older elderly population in the future. Increasing health spending with age accompanied by population aging implies an increasing aggregate health expenditure in the future, even when other factors remain constant.

Previous projections of health expenditure have been usually carried out by combining a constant (over time) age-sex specific health expenditure with deterministic scenario-based population projection (see Majal and Berman, 2001 for a survey). However, it has been shown repeatedly that both age-sex specific health expenditures and the population structures in the future are highly uncertain and most projections turned out wrong. Therefore, the projections based on the traditional approach are often unhelpful in evaluating future health care expenditures. In this project we will try to improve upon the existing literature by incorporating uncertainties in population projection and future age-sex specific health expenditure.

Health expenditure amounts to a large share of GDP in most countries and its larger part is financed by the public sector. Many countries have National Health Systems (NHS) that both channel funds and provide comprehensive direct health services to the population. Typically, in a medium sized country, a standard NHS faces up every day the demands of several millions of individuals organizing a wide variety of resources, from manpower to consumables or to large plants, or from very basic to highly sophisticated, in order to keep in due shape the health status of the population.

Aggregated health costs are fuelled by a number of determinants that range form the sheer number of potential patients to the technological content of treatments without disregarding differential inflation of health services or morbidity rates among the population. Among the latter, one typically finds the fact that healthier lifestyles or new therapies may reduce morbidity. But one also finds that new types of pathologies or health related needs are spreading among ageing populations. These risks are simply generalizing as individuals live longer on average thus exposing health problems so far restricted to a handful of individuals of advanced age. The structure of the population also determines to some extent the structure of the output of the health system and, as the cost of age specific treatments differs, the evolution of health expenditures as ageing advances. Every factor pushing health expenditure has an evolution that can be properly tracked in order to infer future trends, but a large degree of uncertainty will typically remain everywhere. A limited series of health expenditure projections would thus have little predictive power even when it comes to a reasonable estimate of high and low scenarios.

This paper within the DEMWEL project tries to discuss the general and specific issues around the projection of health expenditures in EU countries under demographic uncertainty. It will first deal with the general concepts and methods of health expenditures and in particular with the construction of an age-specific per capita health expenditure pattern that will be used later for projection purposes.

Projection procedures will be discussed next and the role of some crucial assumptions explained. A rather common bias is introduced in health expenditure projections based on demographic projections when fertility and mortality assumptions are not properly dealt with. That is, on the one hand, the standard assumption of changing fertility with time on the population side is not followed by a correction on the health side to account for corresponding variation in maternity related health care among women of fertile age. On the other hand, once health related expenditures by age are split into those incurred by survivors and those by decedents the projection of aggregated health expenditures may change due to the composition effects induced by varying shares of survivors and decedents over time.

Uncertainty within the DEMWEL project will be mainly dealt with by using stochastic population projections methods as developed by J. Alho and colleagues. As for this part of the present paper we will discuss the main issues involved in properly dealing with uncertainty surrounding health care whereas the effects on health expenditure due to uncertainty surrounding population trends will be dealt with at a later stage.

2. Modeling health production and expenditures

According to the *human capital model* of health (Grossman, 1972; 2000) which is based on the commodity demand theory by Becker (1965), health is both a consumption commodity and an investment commodity. As a consumption commodity, it directly enters their preference functions. As an investment commodity, it increases the productivity both in the market and at home. In a life cycle optimization framework, people invest in health capital to maximize their lifetime utility where lifetime is endogenous as it is affected by health investment. Unlike other human capital such as schooling, health is not a direct choice variable. Given the inherited initial health stock, one can affect his/her health status through health-related investment (in terms of both money and time). Health production function relates health output to such choice variables or health inputs, such as health care service utilization, diet, exercise, smoking, and other health-related behavior. In addition, the production function is affected by the efficiency or productivity of a given consumer as reflected by his or her personal characteristics. Final health outcomes also depend on other factors such as genetic endowment, environment and chances.

Human capital models of health are useful to understand who, and in what circumstances, are more willing to pay for different types of health care service for given health status and prices. They are less useful in a society where most health care services are provided free of charge by the public health system. Under the free health care system, although people still has to make many health-related decisions and the shadow price of the utilization of medical care may vary according to their characteristics, empirical relevance of the model in relation to health care expenditure becomes substantially reduced.

Conceptually, an individual's health care expenditure at a given age depends on his/her health status at this age and the usage rate of health care services given health status, and the unit price of health care service. Health status, in turn, depends on past health behavior (investment), genetic endowment and environment, and chances. The usage rate of health services for given health status, in turn, depends on individual characteristics and social norms (both of which form individual's preferences) as well as their direct and indirect costs. All three elements contain a large random component and are interrelated in a complex manner. Therefore, the main problem with health care expenditure is that it is considerably more uncertain and difficult to model than other types of public expenditure. For example, pension legislation and work/retirement decisions provide a framework for future pension expenditure. No equivalent framework is available for the demand and supply of health care.

Given this uncertainty and complexity which will determine final health expenditure, structural modeling which considers all the factors as well as supply-demand interactions which determine the price lies beyond our reach. Therefore, we consider a reduced form approach.

2.1. Macroeconomic Models

Most macroeconomic models of health expenditure are motivated by large cross-country differences in health expenditure and an apparent weak association between the expenditure level and population health status. Thus, a main objective of the macro models has been to search for macroeconomic and institutional variables which explain the differences in the level and their efficiency of national health expenditure across countries. One of the variables often included in the models is population age structure, usually in the form of the proportion of population aged over 65 years.

Empirical results, however, have shown insignificant effects of population aging contradicting well-established microeconomic evidence of a *J*-shaped age profile of health expenditure (see Gerdtham and Jönsson, 2000 for a survey). The lack of effect of population age structure in macro models is likely to be due to a small sample size and uncontrolled heterogeneity across countries. Some improvements can be achieved combining cross-section with time-series data in panel analyses (for example, Gerdtham, 1992). Nonetheless, many problems remain such as data reliability, misspecified equation, short length of panel, and lack of theory as concluded in Culyer, (1988). Empirical results of panel analyses have shown similar insignificant effects of population composition on health expenditure. Therefore, the projections based on a reduced form macro model estimation would provide the future health expenditure insensitive to population aging (Zweifel *et al*., 1999; Mayhew, 2000).

Warshawsky (1999) attempts to project health care spending using a two-sector and two-factor general equilibrium model, with health sector being one of the sector, and all other activities being the other. Health care is produced according to a Leontief type (fixed ratio of labor and capital), while output of the rest is a result of Cobb-Douglas production. The model takes savings to be a constant proportion of income and takes labor supply to be a function of demographic and sociological factors. The author makes assumptions about the price and income elasticity of health care. The model is useful in that it is able to explicitly take into account at least some of the interrelationships that are characteristic of the process of demographic transition, aging and economic development. However, it is far too aggregate and simplistic in its scope to capture individually the influences of the several factors that affect health care spending. Furthermore, the model lacks micro foundation which defines individual behavior regarding health expenditure. Therefore, the model's usefulness in health expenditure projection is very limited.

2.2. Demographic Models

A simple demographic approach to project health care expenditure which considers population aging is to combine age-specific expenditure with population age composition as in the following identity:

$$H_t = N_t \sum_{i=0}^{I} h_{it} \pi_{it}$$

where H_t is total health expenditure in year *t*, N_t total population, h_{it} per-capita health expenditure of age group *i*, and π_{it} the population share of age group *i*. From this identity, we can see that age is linked to aggregate health spending in two ways: per-person health spending which may vary across age groups, and the share of each age group in total population. Over time, aggregate health expenditure can vary due to the changes in any of the three components, total population, age composition and age-specific per-capita expenditure. Provided that a reasonable projection of population (total and age composition) can be obtained, the main problem boils down to how to obtain age-sex specific health expenditure in the future.

One simple but naive solution is to assume that current age-specific expenditures stay constant for the future. Even in this case, it is not an easy task to obtain a *reasonably good* current age-specific health care expenditure. Usually we do not have much data for that purpose. The problem complicates even more as both public and private health care systems coexist in most countries. The proportion of public health expenditure ranged from 70% in Netherlands, around 75% in Spain, Germany, France and Finland, 84% in the UK, to 90% in Belgium at the end of the 1990s. Therefore, the major share of health care expenditure is provided by the public finance, but the private share of health expenditure is also substantial in most countries.

3. Health care expenditures and population structure

3.1. Types of health related expenditures

Health related expenditures, at large, are those expenses incurred by individuals, or by other agents on their behalf, to restore, keep and improve their health status and to overcome in whole or in part functional impairments and disability. In the above sense, long-term care expenditures would be part of health expenditures. However, given the difficulty to gather reliable data on this type of expenses and that, in a way, the corresponding services are very different from strict health care it will not always be possible to take them into consideration for projection purposes. Ironically, given ageing, these type of expenses would likely grow at a very fast pace in the coming years. It is thus very important to bear in mind the limitations of any exercise that do not consider this type of care fully.

It is customary to split health expenditure into private and public health expenditure the latter being that part of total expenditure that the public sector undertakes to provide health services to individuals either directly or through qualified third parties. Public health expenditure is the matter of our exercise in this paper and we will distinguish among the following three broad categories:

- Hospital based care (in-patient)
- Non hospital based care (out-patient)
- Pharmaceutical expenditure

One of the reasons for this particular breakdown is that very often detailed data sources are specifically built for categories equivalent to those. For instance, the cost of in-patient or hospital based treatments, that often include major surgery not requiring a stay at a hospital, have been tracked since the mid eighties in many countries with a dedicated methodology based on "Diagnostic Related Groups" or DRGs, that is, mixed-case super-treatments involving a series of treatments requiring similar lengths of stay and other resources and whose average cost characterize the whole DRG. All patients having undergone any of the treatments within a given DRG are captured by the data collection protocol together with some of their characteristics like gender, age and whether they died or recovered and left for home. This approach is followed by almost all hospitals in National health Services and by many private hospitals. This methodology was introduced in the US in 1983 by the federal health scheme for salaried workers, Medicare, and has been since then widely adopted as a benchmarking device to control medical costs.

Out-patient treatments are not so carefully evaluated from an economic point of view and their cost must be inferred using approximations based on aggregated figures and patterns of consumption obtained from surveys. Pharmaceutical expenditures are known generally with detail but neither can they be assigned easily to individuals of different gender, age, etc. Again, consumption patterns by gender and age can be obtained from surveys and imputations made that allow the researcher to recover the aggregate figure.

Our exercise thus will consist in establishing age profiles for per capita public health expenditure linked to hospital based care, non hospital based care and pharmaceutical consumption.

3.2. Age-Sex Specific Health Expenditure

The first important task in the projection of health care expenditure is to measure with sufficient precision the age-sex specific expenditures for the most recent years. If we are not sufficiently confident of the measured profiles, we obviously can not have any confidence of the projections based on them. In most studies (for example, Mayhew, 2000; EPC, 2001; Dang *et al*., 2001) which carry out projections of health care expenditure based on current age profiles of health expenditure, there is no explanation about data source and computation method.

Some studies provide more detailed information on the data source used for the calculation of age profiles of health expenditure. For example, Polder *et at*. (2002) calculates age-specific acute care (hospitals) expenditures in the Netherlands using comprehensive data on all hospital admissions and interventions by age and intervention categories in 1988 and 1994, while Denton *et al*. (2002) calculates age profiles of the public expenditures on physician services using a comprehensive data set on billings by fee-for-service physicians in the province of Ontario (Canada) in 1995-1996.

In the following, we describe our strategy to calculate age-sex profiles of health expenditure, separately for the private and the public expenditures.

For the private out-of-pocket expenditures we can use household expenditure surveys as they are available in many countries. Even in this case, a problem arises since most expenditure surveys collect data at the household level. This problem can be overcome using a regression method which distributes household expenditure to each individual member of the household as in the following equation.

$$E_k = \sum_{i=0}^{I} e_i n_{ik}$$

where E_k denotes health expenditure in household k, n_{ik} the number of persons in *ith* age interval in the household k, and e_i the age specific health expenditure to be estimated. The equation can be estimated by OLS or Tobit if there are zero expenditures in the sample. In using this approach, we need sufficiently large sample sizes to reduce the standard errors of the estimated coefficients.

For the public health care expenditure, micro surveys do not help as it is usual that the expenditure is not paid directly by users. We have to rely on other alternatives such as DRG (Diagnosis-Related Groups) measures which estimate unit costs of treatment of each type of illness. Combining the DRG unit cost measures and the frequency of each DRG treatment by age and sex we can obtain age-sex profiles of public health care expenditure. In the countries where health care services are financed publicly but are provided by the private sector, administrative data on the insurance reimbursement records will serve a similar purpose. This part therefore will depend on the availability and reliability of relevant data. This discussed more specifically below.

3.3. Factors behind the evolution of health expenditures

The basic accounting model of health expenditure

Total health expenditure at year *t*, H_t, is the result of:

- applying a number of units of resources of type $r = 1 \cdots R$, h_r
- with unit cost p_r
- to each of a number of patients of age $i = 0 \cdots I$, m_i
- that require any of a number of available health process $j = 1 \cdots J$ (a DRG, typically)[1]

After taking proper care of subscripts H_t can be expressed as:

$$H_t = \sum_{i=0}^{I} \sum_{j=1}^{J} \sum_{r=1}^{R} p_{rjt} h_{rjt} m_{ijt} \qquad (1)$$

Health inputs of type *r* can be shared by different health processes of type *j* and also technological and organizational advances may change the type and the amount of resources needed by any *j* process. In a way, each health process has its own technology. So innovations have a say on health expenditure, but not necessarily to lower it.

Unit costs, on the other hand, may change according to market conditions at different pace than general inflation thus distorting the real cost of any health process.

Morbidity and the age structure of population are also crucial in determining the aggregate health expenditure. In order to see it let us decompose the number of patients of age *i* undergoing process *j* at time *t*, m_{ijt}, in the following way:

[1] Even if health processes are readily understood when defined as complete hospital treatments since admission till discharge either by *exitus* (death), recovery (survival) or transfer to other hospital, this term can also be applied to out-patient protocols since first to last consultation or cure. As said before, out-patient treatments are not so thoroughly costed and there is lack of data about them. For the sake of our argument here, however, we will consider these as proper health processes. The same applies to pure pharmaceutical treatments while pharmaceutical inputs delivered as part of in-patient processes are typically included in the overall costing of such processes.

$$m_{ijt} = \frac{m_{ijt}}{n_{it}} \frac{n_{it}}{N_t} N_t = \mu_{ijt} \pi_{it} N_t \qquad (2)$$

where μ_{ijt} is the morbidity rate for "disease" *j,* to which process *j* is also applied, among individuals of age *i* at year *t* and π_{it} is the share of individuals of age *i* in total population at year *t* with the distribution $\{\pi_i\}_0^I$ representing its age structure.

Morbidity has to do with genetics (and wear and tear) as much as with environmental and behavioral factors for it is nothing else than the incidence among the population of standard diseases and casualties. It has also to do with gender, although for the sake of simplicity of notation we have not explicitly represented so far this dimension. While morbidity from certain diseases goes down among developed populations, other diseases (dementia at old age, for instance) are on the rise. Obviously, changing lifestyles o exposure to environmental factors will affect morbidity while new genetic therapies will rather affect the input mix and its cost of the processes applied to cure. Genetic or other types of vaccines that aimed at reducing *ex ante* morbidity however would be part of overall out-patient expenditure.

A changing age structure of the population would also affect health expenditure as morbidity, process and resources bear differently for individuals of different age (and gender). A more aged population, given population size, cannot but increase health expenditure as non-fatal health costs are much higher on average for older than for younger individuals given their higher morbidity rates. Costs for decedents, on the other hand, tend to be higher for young adults than for older persons, as we will show latter.

A changing population, finally, would, other things being equal, imply a direct effect on aggregate health costs.

The five horses of health expenditure

Combining expressions (1) and (2) we obtain:

$$H_t = \sum_{i=0}^{I} \sum_{j=1}^{J} \sum_{r=1}^{R} p_{rjt} h_{rjt} \mu_{ijt} \pi_{it} N_t \qquad (3)$$

where the five major determinants of aggregate health expenditure are easily identified together with their dimension of relevance (age, type of process and type of input).

As for the evolution of health expenditure with time, provided that each factor follows a time process that is independent from one another, a general expression can be found (Mayhew, 2000) of the form:

$$H_t = H_{t-1} e^{g_{pt} + g_{ht} + g_{mt} + g_{st} + g_{Pt}} \qquad (4)$$

where g_{kt} is the rate of growth of the k^{th} factor affecting health expenditure in year *t*.

Note that for the sake of this exercise we will only be interested in two of the five factors represented in expression (3) above, population structure and population size as given by the population projections (stochastic or not) available to us. This means that real health expenditure per individual of given age (and gender) will remain constant all through the projection period. In particular, this means that health input prices, the diversity and intensity with which these inputs are used and morbidity among age (and gender) groups will remain constant. We know however that this has not been the case in the past and that at present a series of promising health technologies are about to break even or certain health-related behaviors are starting to change, but we want, on the one hand, to isolate the effects of population change and, on the other hand, we lack appropriate knowledge of the process followed by the rest of the factors in order to be able to project their likely future development.

3.4. The age pattern of per capita health expenditure

In-patient health care costs

As said before, data for this kind of cost estimation is abundant through the DRG methodology. Typically, these data can be obtained in a disaggregated way with actual cases for each DRG of given cost. Once this information available the computation of average expenditure on this type of health services is straightforward. The information available for Spain is shown in Table 1 below. It can be seen that very valuable information is contained starting with the total number of discharges for each DRG and their ages and gender. Then, it is possible to know whether the patient has been before in hospital during the previous month. The cause of leaving the hospital is also known whether full recovery, *exitus* (death), voluntary leaving or removal to other hospital or care centre. An average cost based on the mix-case methodology of the DRG construction is imputed to each of the patients having undergone the treatments embraced in any particular DRG and the precise nature of these treatments is also recorded following a pre-established list of principal and secondary diagnostics, as well as the major surgical or obstetrical procedures applied to the patient.

Table 1
Individual information available for each DRG (a)

	Personal characteristics	Medical-Surgical information	Administrative information	Economic information
For each DRG (b)	Age Gender	Principal diagnosis Secondary diagnosis Main surgical-obstetrical procedure	Nº of discharges Type of hospital (nº of beds, 5 cat.) Length of stay (days) Is the patient back to hospital? (2 cat.) Cause of leaving hospital (5 cat.) Who is paying the treatment (9 cat.) Who decided hospitalization (2 cat.)	Average cost of the treatment (c)

(a) Only the relevant items are listed below. Of course, the administrative records for each patient at hospital admittance have more personal information as well as the clinical records during the stay that are confidential and not available to us.
(b) The Spanish NHS has 805 DRGs defined
(c) applies equally to all patients under the same DRG

This type of health care expenditure accounts for more than 50 per cent of total public health care expenditure in Spain.

Out-patient health care costs

There is no comparable data as for health care delivered to individuals either outside hospitals or inside them but not requiring major surgical procedures already included in the DRGs coverage. This type of care is however very important accounting for a large share of total public health expenditure. In Spain it accounts for 15,5 per cent in 1999.

A possible way to approach the computation of an age pattern for this type of expenditure is to build an age pattern of the utilization of these type of services by the population and then impute an average cost to a theoretical unit of care. This theoretical unit is in fact a composite index of use obtained from standard health surveys carried out in many countries. In these surveys individuals of all ages and gender are asked about their use of health services at health centers or at home provided by the NHS. Among these services one finds consultations and treatments. Then one can compute the probability of using these services by individuals of given age-gender and the average consumption by a representative individual of each age-gender within the national population. Dividing the total expenditure on these health services at any one year by the re-scaled total number of units consumed by the population in the same year it is possible to get a crude estimate of the unit cost of these services. From here, the estimation of an age pattern is straightforward.

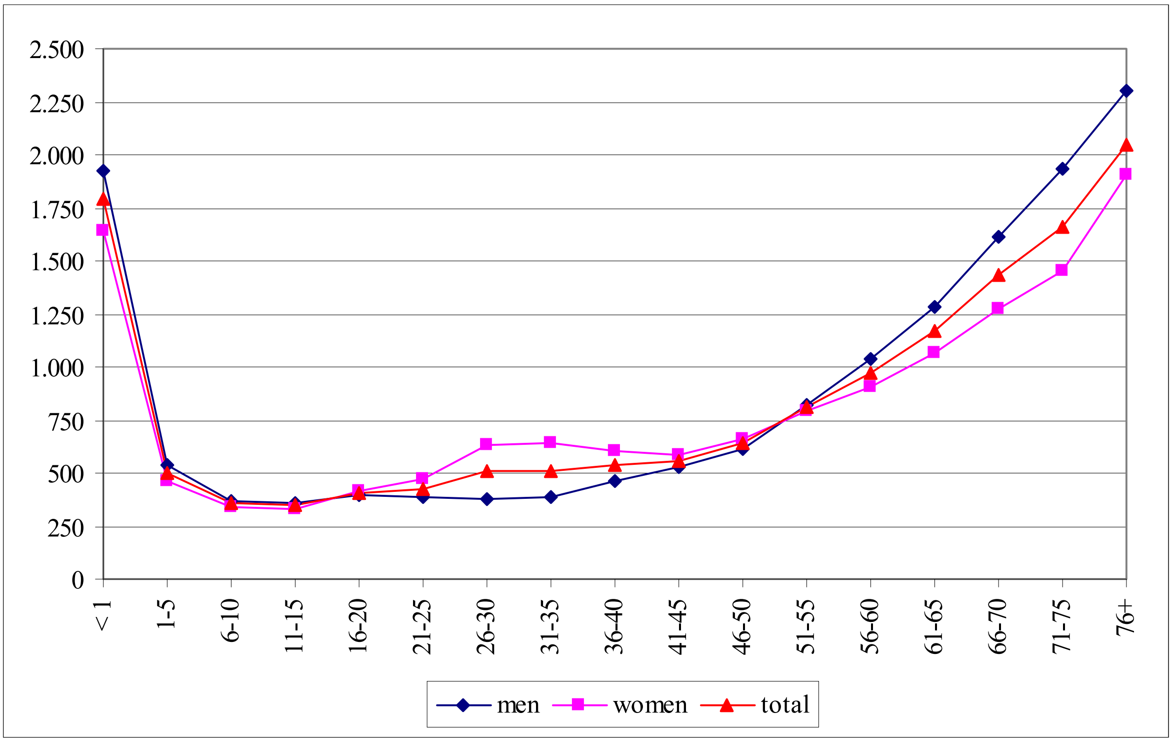
Pharmaceutical expenditure

These expenses account for about 22 per cent of total public health expenditure in Spain (1999) and have similar magnitude in many other countries. Pharmaceutical consumption by individuals of a given age-gender can be traced, although in an imperfect way, using National Health Surveys. The same procedures described above may be used to estimate an age pattern of this type of health service consumption by individuals.

The "J" age pattern of per capita health care costs

Either applying the very detailed method behind DRGs or the far more crude methods described in the last two subsections one systematically finds an age pattern whereby babies of less than one year require much more care than children, teens or adults. Aged persons also require an increasing mix of care as their age increases. In fact, health care services consumed by individuals above 40 years of age increases with age at an accelerated pace. By gender, at childbearing ages (20-40) women has higher health expenditure while at ages over 55 men incur higher health expenditure. This age profile is similar to the well-established profile. The Spanish pattern (Ahn et al, 2003) is shown in Graph 1 below.

Graph 1
Per-Capita Public Health Expenditure (euros) in 1999 - Spain



Source: Ahn, Alonso y Herce (2003)

4. Demographic Uncertainty and Age Profiles of Health Expenditure

There are three uncertain components in the projection of population: fertility, mortality and migration. These demographic uncertainties are intrinsically related with the uncertainties in the future age-sex profiles of health expenditure even if other factors such as unit costs, technology and morbidity, are held constant.

4.1. How to incorporate fertility rates in age profiles of health expenditure?

Different fertility rates affect health care expenditure in two ways. First, different fertility rates imply different numbers of new-born and therefore total expenditure. This is easy to incorporate once we know the population by age and the age-specific health expenditure. Second, they imply different numbers of women who give birth, therefore different rates of hospital use among the fertile-aged women. To incorporate this, we need an estimation of annual health care expenditure separately for women who give birth from those who do not. Assuming that the health care costs of a birth-giving woman are the sum of the health care costs of a non-childbearing woman and child-delivery costs, we can recover the health care costs of the two types of women using the following formula:

$$H_i = \beta_i \left(H_i^0 + b_i \right) + \left(1 - \beta_i \right) H_i^0 \qquad (5)$$

where the subscript i denotes age of a woman, β the probability of giving a birth, the H^0 denotes health care costs for a non-birth-giving woman, and b birth-giving costs. As we have information on age-specific health care costs (H_i), fertility rate (β_i) and birth-giving costs (b_i), we can recover health care costs for a non-birth-giving woman (H_i^0) and a birth-giving woman ($H_i^0 + b_i$).

An example of how we can compute health care expenditure by child delivery status is shown in Table 2 below. In Spain, the unit cost of child delivery which includes delivery costs and post-natal nursing costs amounted to 2,456 euros in 1999. Given age-specific hospital care expenditure (H_i) and the proportion of the population (b_i) who used public hospitals for child delivery during the year, we can compute the hospital care expenditure separately by birthgiving status using the above formula.

Table 2
Health Care Costs by Child delivery Status: Spain 1999

Age	Number of births	Population	Proportion	Hospital care expenditure (euros)		
				All	Childbearing women	Rest
16-20	11,781	2,740,359	0.0043	146	2,591	135
21-25	35,971	3,290,278	0.0110	171	2,600	144
26-30	87,642	3,343,593	0.0262	232	2,624	168
31-35	93,586	3,253,387	0.0288	278	2,664	208
36-40	33,885	3,035,063	0.0112	253	2,682	226
41-45	4,574	2,708,372	0.0017	260	2,712	256

The proportion who gave birth is much lower than the age-specific fertility rate mainly due to the inclusion of males in the base population. Furthermore, not all the births are delivered in public hospitals. About 3 out of each 4 births are delivered in public hospitals.

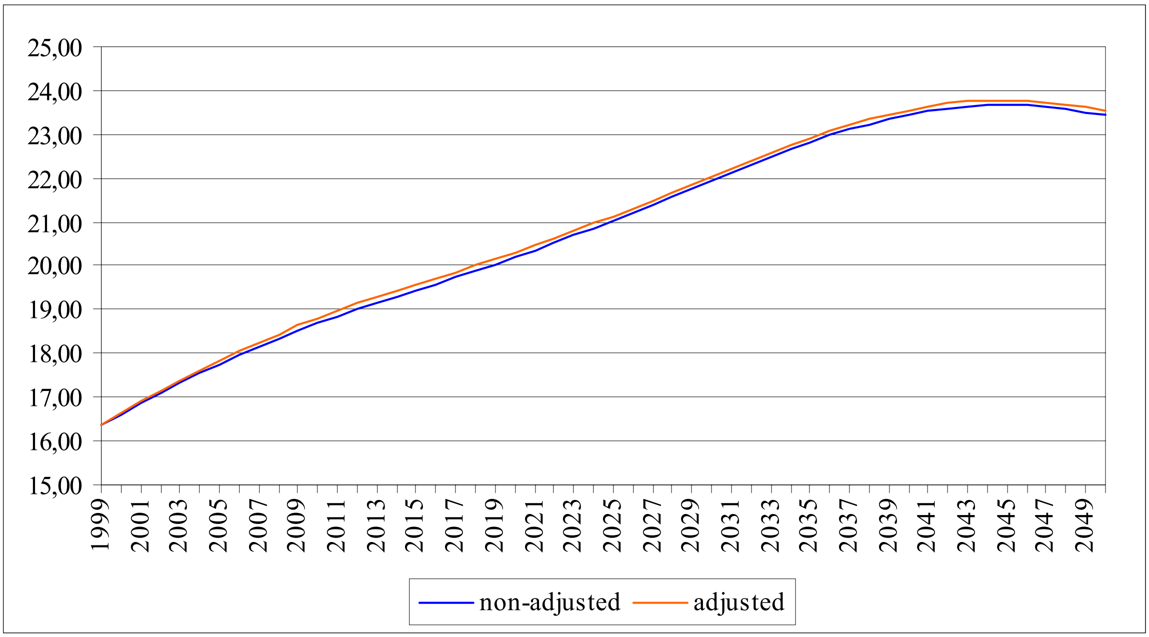
Now, to measure potential impacts of different fertility rates on age-specific health expenditure, we compute age-specific health expenditure under the assumption of the fertility rate twice higher (i.e. doubling the number of births) while holding other things constant. Under this assumption, per-capita health care expenditure among the fertile-age (16-45) population increases by about 10%, from 225 euros to 254 euros. This rather small impact, in spite of doubling the number of births and the enormous differences in health expenditure by birth-giving status, is obviously due to the small proportion of the population who give birth.

When projecting health expenditure based on a population projection that has the assumption of time-varying fertility rates, one has to consider the corresponding variation in maternity care costs.

4.2. How big is the fertility bias?

We can illustrate the consequences of adjusting varying maternity rate over the projection period using the Spanish data for 1999 obtained from the DRG national database. This can be seen in Graph 2. As we see, total expenditure after adjustment is higher than without adjusting for maternity costs but the difference is small since the fertility rate increases from 1.2 to 1.4 over the projection period and because the share of health care expenditure of the childbearing age group is relatively small in total expenditure.

Graph 2
Total public health expenditure to 2050 (bn. euros)
Adjusted and non-adjusted by varying maternity costs



4.3. How to incorporate mortality rates?

Age-specific mortality rates determine life expectancy at each given age. On the other hand, it is by now a well established fact that health expenditure is concentrated during the last year (or last quarter) of life (Lubitz and Riley, 1993). Therefore, as mortality rates decline, the average length of remaining life (or time until death) increases at any given ages. That is, at each given age the proportion who are in their last year of life diminishes as the mortality rate decreases. This will tend to decrease age-specific health expenditure at any given ages. However, it is not yet well known if the increases in longevity is due to a prolongation of life in bad health or in good health (expansion vs. compression of morbidity) which will affect age profiles of health expenditure of survivors as well as decedents. The final effect of mortality decline on age-sex profiles of health expenditure will depend on the relative importance of each of these factors. This point should be considered seriously if the population projection is based on a relatively large improvement in mortality rates at old ages. Stearns and Norton (2002) and Seshamani and Gray (forthcoming) consider the effect of changing time to death in their projections of health expenditure. However, they do not consider the other aspect, expansion or compression of morbidity.

Confounding the effects just discussed is the observation that a part of decline in mortality among the elderly is due to the increasing per-capita health expenditures which provide more and better health care services (some evidence in Lichtenberg, 2002). Therefore, one has to consider this causality in projecting future health expenditure if decreasing mortality rates are assumed in their underlying demographic projection.

In practice, we incorporate the effects of different mortality rate on aggregate health care expenditure by considering different health care costs by survival status. The health care costs for a person aged *i* is the weighted average of that of the deceased and the survivors:

$$H_i = m_i H_i^d + (1 - m_i) H_i^s \qquad (6)$$

where *m* denotes the probability of dying, the superscript *d* denotes deceased and *s* denotes survivors. Therefore, we need to have estimation of health care costs separately for the deceased and survivors.

So far, there are a few studies which estimate separately by survival status:

- Lubitz and Riley (1993): Using the US Medicare program data, they show that per-capita annual healthcare costs was $13,316 for decedents and $1924 for survivors in 1988 among the population aged 65 and more.
- Calfo, Smith and Zezza (2003): According to the US Medicare program data, in 1999 $24,856 for each decedent and $3669 for each survivor among the population aged 65 and more.
- McGrail, Green, Barer, Evans, Hertzman and Normand (2000): According to the data from the province of Brithish Columbia (Canada), in 1993 per-capita medical and social care costs during the last 6 months of life for decedents (survivors) were Canadian $19,053 ($1139), $22,112 ($2557), $26,245 ($6967) and $27,152 (10,779) for decedents in ages 65, 75-76, 85-87 and 90-93, respectively.
- Seshamani and Gray (2004): According to the data from Oxfordshire (UK), per-capita hospital cost in the last year of life is 3 times higher than that in the second year before death, 10 times higher than that in the 7th year before death and 20 times higher than that in the 15th or earlier years before death.

Obviously, the magnitude of the impact of changing mortality rates on per-capita health expenditure depends on the magnitude of improvement in mortality rate and the differences in per-capita expenditure by survival status. The greater the mortality improvement and the greater the differences in expenditure by survival status, the greater will be the impact. Table 3 illustrates this impact using the health cost estimates from the study by McGrail *et al.* (2000) and hypothetical mortality rates for 2000 and 2020.

Table 3
An Illustration of Impact of Mortality Rate Decrease on Health Cost

	Mortality rate		Health Costs - 2000		per-capita health cost		ratio
Age	2000	2020	Decedent	Survivor	2000	2020	2020/2000
65	0.02	0.01	19,053	1,139	1,497	1,318	0.8804
75	0.04	0.02	22,112	2,557	3,339	2,948	0.8829
85	0.10	0.05	26,245	6,967	8,895	7,931	0.8916
90	0.20	0.10	27,152	10,779	14,054	12,416	0.8835

Source: McGrail *et al*. (2000) and own computation

In the above example, we assumed a reduction of the mortality rate by 50% between 2000 and 2020. This is a substantially more optimistic assumption than that used in the projections by the Eurostat or national sources for most European countries. The ratio of health costs between a decedent and a survivor ranges from 17 at age 65 to 2.5 at age 90. Per-capita health cost in each year is calculated as a weighted average of health costs of decedents and survivors using the health costs in 2000. The decrease in per-capita health costs between 2000 and 2020 is a little over 10% at all ages.

4.4. Estimation of health care expenditure by survival status using DRG information

In most countries, the type of longitudinal data needed for separate estimation of health costs by survival status is inexistent. One possible solution is to use DRG information. Minimum necessary information for the purpose is average expenditure, mortality rate, and number of treatment by age groups for each DRG category. A crucial information for our purpose is the reasons for discharge, one of which being death (*exitus*). For the case of Spain, we have information on the number of treatment for each DRG by 5 year age intervals with 86 and more as the highest age category. As for the average costs per treatment and the mortality rate for each DRG, they are not disaggregated by age groups in our data. We assume that they are, within each DRG, same across age groups. Therefore, the differences in health costs between age groups and by survival status arise due to the differences in treatment frequency by age and different mortality rates between different DRGs.

In Table 4, we present per-capita public hospital care costs by survival status in Spain for the year 1999. First, we have to notice that the number of deaths accounted in the public hospital as the reason of discharge is much smaller than the total number of deaths which were about 360,000 in 1999. This difference are due to the fact that many patients with a terminal disease are discharged from hospital before death. In these cases the treatment costs are assigned to survivors simply because we do not know when they died. Therefore, the costs for survivors are likely to be overestimated.

First, we observe much larger per-capita hospital care costs for decedents than for survivors. The cost ratio between the two groups reach a maximum of almost 100 to 1 at ages 16-20 (mostly traffic accidents for decedents) and a minimum of 5 to 1 for those aged 86 and more. The ratios are more or less comparable to the estimates of other countries as mentioned earlier. For example, in the Canadian province of British Columbia (McGrail *et at*., 2000), the per-capita medical cost ratios between decedents and survivors were 19 at age 65, 12 at ages 75-76, 6 at ages 85-87 and 5 at ages 90-93.

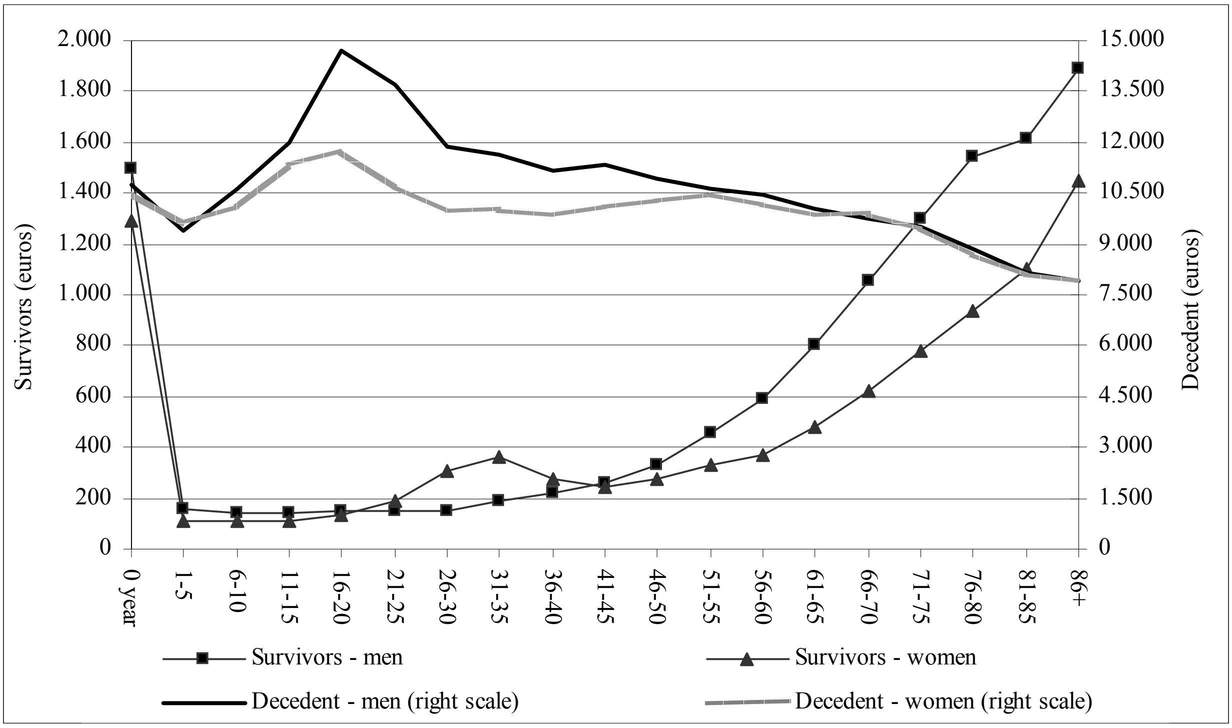
Table 4
Public Hospital Care Costs by Survival Status: Spain in 1999

Age	Population (in 1000)	# decedent in public hospitals	% decedent	Costs per decedent	Costs per survivor	Average costs	Cost ratio decedent to survivor
0 years	380	1297	0.341	10639	1398	1425	7.6
1-5	1837	453	0.025	9476	133	135	71.1
6-10	1982	449	0.023	10392	127	128	82.1
11-15	2182	514	0.024	11709	126	129	92.7
16-20	2740	844	0.031	13632	141	145	96.5
21-25	3290	1135	0.035	12552	166	170	75.6
26-30	3344	1400	0.042	11104	227	231	48.9
31-35	3253	1907	0.059	11031	271	277	40.7
36-40	3035	2167	0.071	10722	245	252	43.7
41-45	2708	2406	0.089	10899	250	259	43.5
46-50	2441	2993	0.123	10731	306	318	35.0
51-55	2328	4153	0.178	10550	392	408	26.9
56-60	1972	4913	0.249	10379	478	500	21.7
61-65	1995	7469	0.374	9992	631	662	15.8
66-70	2020	10835	0.536	9803	821	865	11.9
71-75	1704	12507	0.734	9464	1003	1059	9.4
76-80	1250	12277	0.982	8777	1179	1247	7.4
81-85	745	9186	1.232	8125	1281	1358	6.3
86+	525	8763	1.669	7902	1581	1680	5.0
Total	39733	85670	0.216	9552	396	414	24.1

Source: Spanish Ministry of Health and own computations

A clearer representation of the age-gender profiles of these per capita expenditures can be observed in Graph 3. It is clear the widely differing scales that apply to each category of expenditure.

Graph 3
Per-capita hospital costs by age and gender and survival status – Spain 1999



Source: Spanish Ministry for Health and own computations

Some drawbacks can be mentioned in our data. First, within each DRG, there is no cost variation by age or survival status, neither any variation in mortality rate by age within each DRG. Second, hospital treatment costs for patients who died at home or at places other than hospital after they are discharged from hospital are assigned to survivors. This tends to increase cost estimates for survivors. However, we think above drawbacks are not too bad since the DRG classification distinguishes to a great extent the differences in age and mortality rate across DRGs.

4.5. Migration

Migration also affects future age-sex profiles of health expenditure as immigrants are likely to have different health status and different health care utilization propensity from natives. If the future population is affected by a large number of immigrants, the projections of future health expenditure should consider this difference. However, there is no an easy way to deal with this effect as no proper data seems to be available so far.

4.6. Projection

Combining the age-sex specific health expenditure with population projection, we project future public health expenditure. Traditionally, projections use a deterministic scenario of future demographic situation. Each scenario uses deterministic paths of fertility, mortality and migration rates. There has been sufficient evidence that this approach is not appropriate due to the existence of considerable uncertainty in future vital rates of population.

Instead of using a scenario-based deterministic population projection, we use here stochastic population projection. A stochastic population projection provides a probabilistic distribution of future population based on stochastic vital processes. Therefore, the projections of health expenditure based on this approach provide a distribution of health expenditure.

5. Stochastic Population Projections 2004-2050

5.1. Method[2]

By stochastic forecast of a population we mean a joint predictive distribution of the future population vectors (Alho, 1999). Predictive distributions are first specified for the vital processes of fertility, mortality and migration. Together with the starting or jump–off population, the future age and sex–specific vital rates determine the induced predictive distribution[3] using the cohort–component book–keeping equation:

Population (t+1) = population (t) + births (t) – deaths (t) + net migration (t).

A description of a stochastic forecast can be given in terms of a point forecast and a random error. Following the cohort–component method, the point forecast gives, for each future year, the most likely population size

Jump-off Values of Population and Vital Processes

Jump-off values of population and vital processes refer to the year immediately before the forecast period. First, we established the jump–off population for Spain using the population as of January 1, 2003, which was taken from the New Cronos database at the en of May, 2004. Second, jump–off values of age and sex–specific mortality rates were established by smoothing the observed values of years 1998–2002 and adjusting for increase during the period to match the level of 2002. Third, age–specific fertility rates in ages 15,…, 49 in year 2002 were used to provide jump–off values. Fourth, jump–off

[2] This section is a summary of Alho (2004).

[3] This distribution takes the place of the conventional projection variants and scenarios to describe uncertainty.

values of net migration[4] at year 2002 were specified based on the most recent officially reported values, level estimated from time-series model.

Point Forecast

The point forecast of mortality was calculated by starting from the jump–off value and applying an age–specific rate of decline during years 2002–2003, …, 2048–2049, to the value obtained until then. From these point forecast, survival probabilities were calculated by sex for each age and forecast year. For fertility, first, ultimate value for the total fertility rate was specified. The total fertility rates of the intermediate forecast years were obtained by linear interpolation. Births were generated for years 2003,…, 2049 using these age–specific fertility rates. With respect to migration, the jump–off values were assumed to persist for ten years. Then, a linear change to the ultimate level was assumed. The age structure of net migration was estimated from data in 1990–2000 and held constant for the rest of the forecast period. Finally, migration during the forecast period was handled in terms of additive net migration values that already incorporate the effect of mortality within the year of entry or exit.

Specification of Uncertainty

To represent the uncertainty of forecasting, we use simulation to establish an estimate of the predictive distribution of the future population by age and sex. cohort–component method was applied 1500 times, with stochastically varying values for age–specific mortality, age–specific fertility, and net migration. The procedure is based on the so-called scaled model for error (Alho and Spencer, 1997), and is implemented by means of the computer program PEP[5]. Uncertainty is assumed to increase with forecast year. Error increments of each age and sex group have a constant non–negative autocorrelation and cross–correlation of errors across age are represented by an AR(1) process, whose correlation at lag 1 is non–negative too. A normal distribution was used to represent error increments for each age and sex–group. Any increasing pattern of error variances can be represented by a suitable choice of the scales of the model. Finally, uncertainty in fertility, mortality, and migration were assumed to be independent of each other[6].

[4] Net migration was defined as the difference in reported population growth and natural increase.

[5] Program for Error Propagation (PEP) is a computer program that carries out stochastic propagation of error using simulation techniques. PEP has written at the Department of Statistics, University of Joensuu. Its application has been illustrated in Alho (1998). For details see Sormunen, Alho and Spencer (1998).

[6] Autocorrelation parameters of error increments and cross–correlation parameters across age and sex in fertility, mortality and net migration are available from the authors upon request.

5.2. Projections results

Total population

Using the PEP programme we performed 1500 projections governed by a set of parameters explained in Annex 1. Basically, the routine starts with a jump-off population and allows shocks to fertility, mortality and net migration to happen every year following a random sequence proper to every projection. This gives us a distribution of total number of population for every year that gets gradually widened as the projection horizon advances and shocks get compounded with previous ones. The frequency distribution of these population number for selected horizons will be discussed later. The resulting population numbers are shown in Table 1 and Graph 1 for selected percentiles of the distribution accompanied by other descriptive statistics and, in the last column, the median simulation under the assumption that there is no net migration.

Note first that the median simulation (P50) entails a gradual increase in numbers up to almost the end of the projection period where total population would reach 44.5 millions or 2.1 millions above the number today. With 50% probability future population would lie between 39.5 and 49.8 and between 35,7 and 54,8 with 80% probability. That is, the population in 2050 may differ by 10 million people with 50% probability and by 20 million people by 80% probability. While we cannot say if these ranges are large or small in itself, they are however rather large when it comes to the economic implications of one or other realisation of total population with their corresponding age structures.

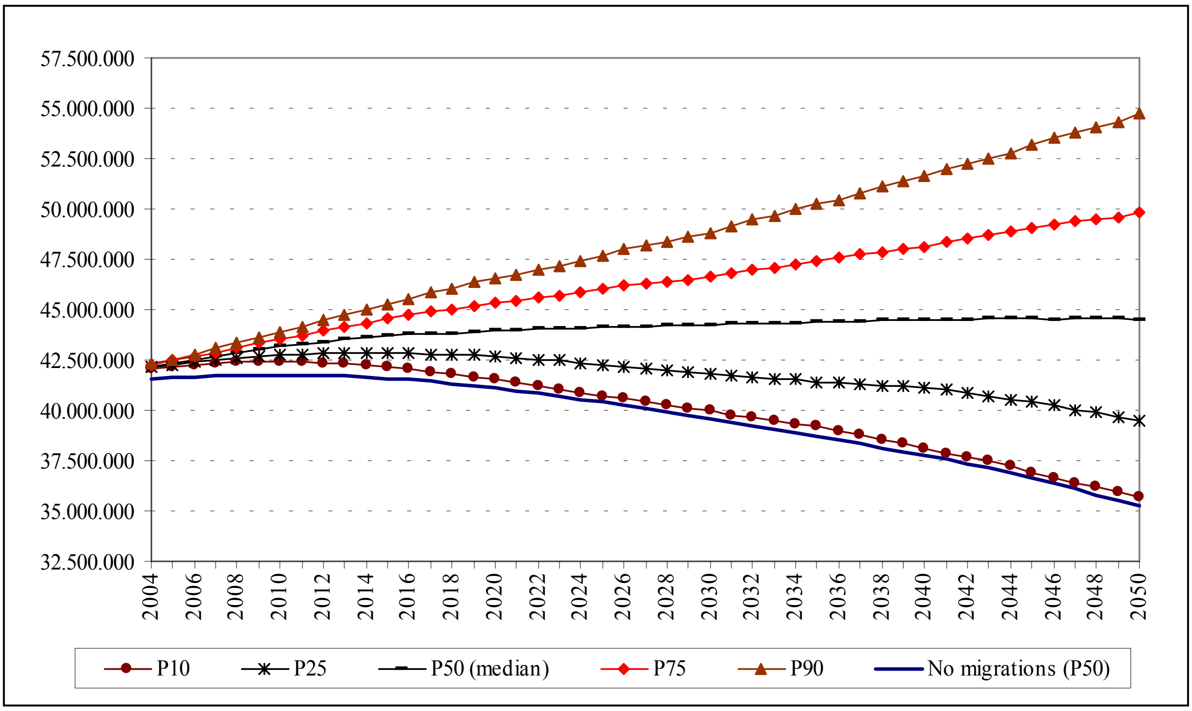
Table 5
Stochastic population projections to 2050 (millions) – Spain
Descriptive statistics and selected percentiles (a)

	Mean	Range (b)	P1	P5	P10	P20	P25	P50 Median	P75	P80	P90	P95	P99	No migration
2005	42,36	0,99	42,04	42,13	42,18	42,25	42,27	42,37	42,46	42,48	42,54	42,59	42,70	41,63
2010	43,15	3,54	41,90	42,21	42,40	42,66	42,76	43,16	43,54	43,64	43,88	44,07	44,41	41,74
2015	43,69	7,20	41,06	41,67	42,15	42,66	42,83	43,69	44,53	44,70	45,28	45,76	46,51	41,59
2020	44,00	10,39	39,94	41,00	41,53	42,32	42,68	43,99	45,33	45,65	46,54	47,29	48,45	41,10
2025	44,16	15,45	38,33	39,98	40,72	41,83	42,25	44,10	46,00	46,48	47,67	48,83	50,28	40,39
2030	44,30	21,08	36,53	38,85	39,96	41,27	41,77	44,20	46,64	47,31	48,82	50,17	52,16	39,57
2035	44,50	27,23	34,72	37,81	39,20	40,77	41,41	44,36	47,44	48,21	50,28	51,91	54,90	38,73
2040	44,68	32,41	33,20	36,45	38,11	40,04	41,11	44,48	48,14	49,17	51,65	53,76	57,48	37,75
2045	44,80	38,09	31,28	34,91	36,93	39,23	40,45	44,57	49,05	50,22	53,16	55,91	60,25	36,62
2050	44,84	45,83	28,96	33,41	35,65	38,33	39,49	44,50	49,82	51,09	54,76	58,04	63,71	35,27

(a) For a distribution of 1500 simulations made with the PEP programme.
(b) Difference between the highest and the lowest population numbers for each year in the whole distribution.

As said before, variability concerning fertility, mortality and migration affect this result. Let us try to infer something about the role played by these factors looking again at Table 5. The last column in Table 5 also shows the P50 simulation if net migration flows were zero. It can be seen that it closely follows the P10 case with migration. This means that the random routines can actually produce zero net migration assumptions. To examine how much of the population distribution in the future is due to migration, we compare the population distribution between the two cases with and without migration. Within the 80% probability (between the P90 and P10), the population range with-migration is about 20 million persons – in 2050 - whereas this range halves for the no-migration simulations. This implies that migration randomness in the PEP routines accounts for about half the population variation while the other half is due to the joint randomness of fertility and mortality.

Graph 4
Stochastic population projections to 2050 - Spain



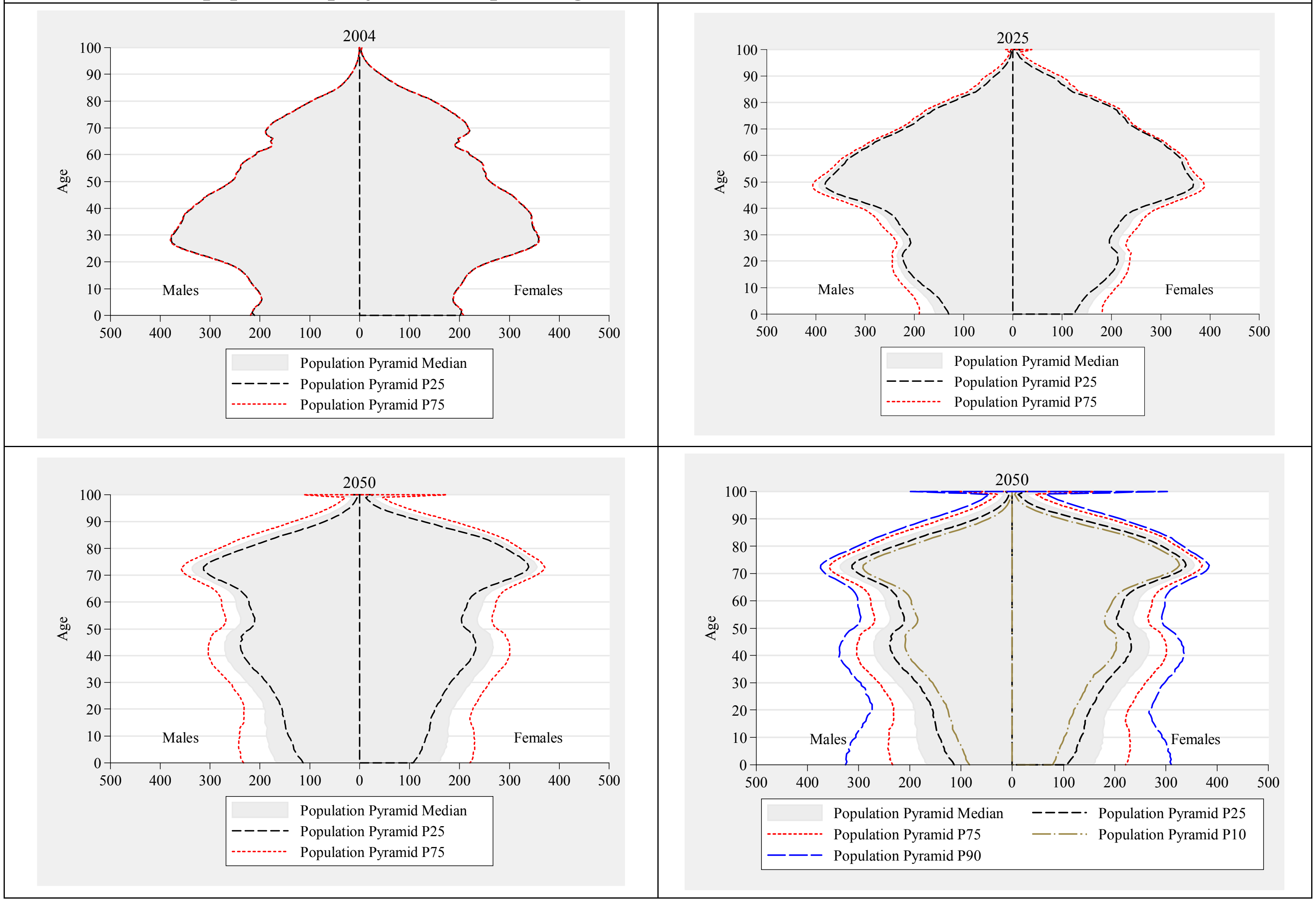
Notes: P10 to P90 refer to percentiles 10 to 90. "No migrations" is the P50 simulation without migration flows.

Age structure

It is well known that age pyramids are becoming "pillars" in Western countries and Spain is no exception to this rule. Our projections show that the age structure of the extremely "unfavourable" simulations can become considerably biased towards high ages while the extremely "favourable" simulations do not allow at all the age structure to recover its pyramidal shape. This is apparent in Graph 5 where for the years 2004, 2025 and 2050 these shapes are represented. As expected, in 2004 no difference is discernible across the distribution of simulations. In 2025, however, differences are clear across the distribution and much more apparent in 2050. The age pyramids for 2050 are duplicated in order to show the age structure at wider variations (10% and 90%). At the 90% highest population distribution, the age structure becomes considerably fatter at the bottom then at top, resulting in lower age dependency ratio.

Graph 5

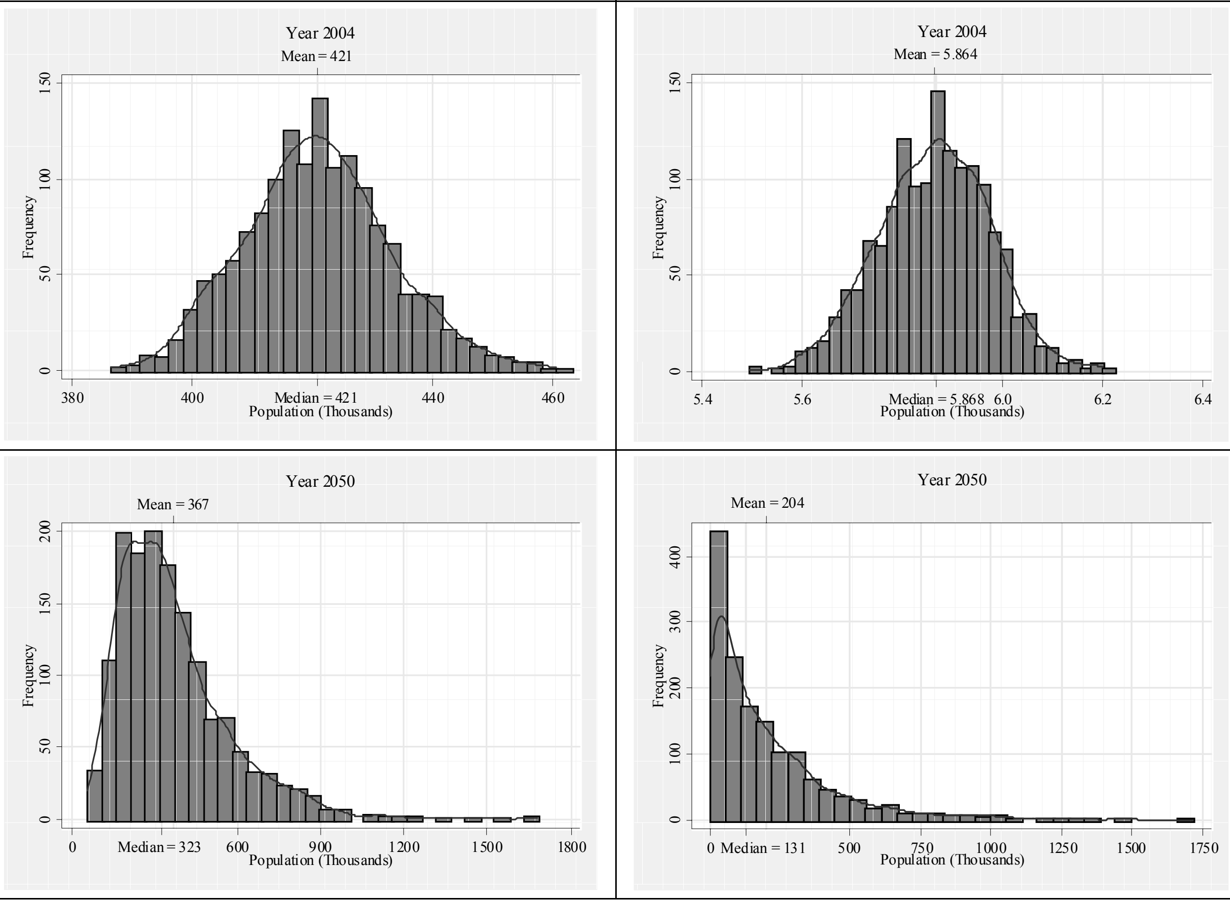
Stochastic population projections – Spain- Age structure and confidence intervals in 2004, 2025 and 2050



It has already been mentioned that migrations explain half the variability of the distribution of simulations but fertility and mortality play also an important role in shaping the age structure. This is apparent in the lower-right pyramid in Graph 6 where P10 and P90 age profiles have been added. At the end of the projection period the variability in the numbers of centenarians and just-born is very large. Both for fertility and survival, the panels in Graph 6 are illustrative of the likely evolution of numbers in these two extreme age groups and, what is more important, the bias that the distribution takes at the end of the projection period.

Graph 6
Simulated predictive distribution of newborns and centenarians 2004 and 2050 (a)

Newborns (population of age 0)	Centenarians (population of age 100 and more)



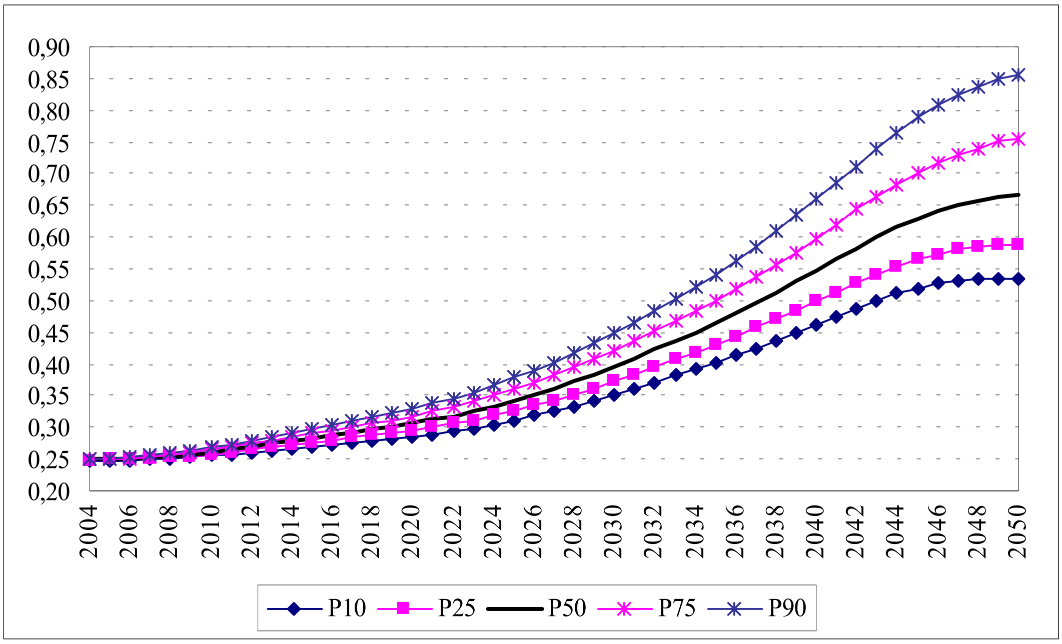
(a) The line enveloping the histogram is the kernel density estimation with gaussian kernel and optimal halfwidth.

In particular, median population of age 0 that amounts to 421 thousands in 2004 would shrink to 323 thousands in 2050 with a relatively high chance of diminishing even more. The median number of centenarians in 2004 that amounts to 5.9 thousands would expand to 131 thousands in 2050 and with a substantial probability of reaching a much larger number.

Dependency rates

The ageing of the population may be shown best through the aged dependency ratios of the population or the elderly ratio. As per-capita health expenditure among the elderly population is much larger than the younger population, this ratio is one of the best indices which could capture the ageing effect on health expenditure. The results that the above stochastic projections entail for the aged dependency ratio are shown in Graph 7. The median projection implies more than a doubling of the current ratio by 2050 (from 0.25 to 0.67) and by about 25% probability it will be higher than 0.75 (triple that of today). At the other side of the distribution, the chance that the ratio lying below 0.54 is mere 10%. That is, the age dependency ratio will be higher than 0.54 in 2050 by the probability 90%. Similar patterns could be shown for total dependency and elderly ratios that are not shown for the sake of brevity.

Graph 7
Projected median (P50) aged dependency ratio and confidence intervals for 50% (P25-P75) and 80% (P10-P90) probability

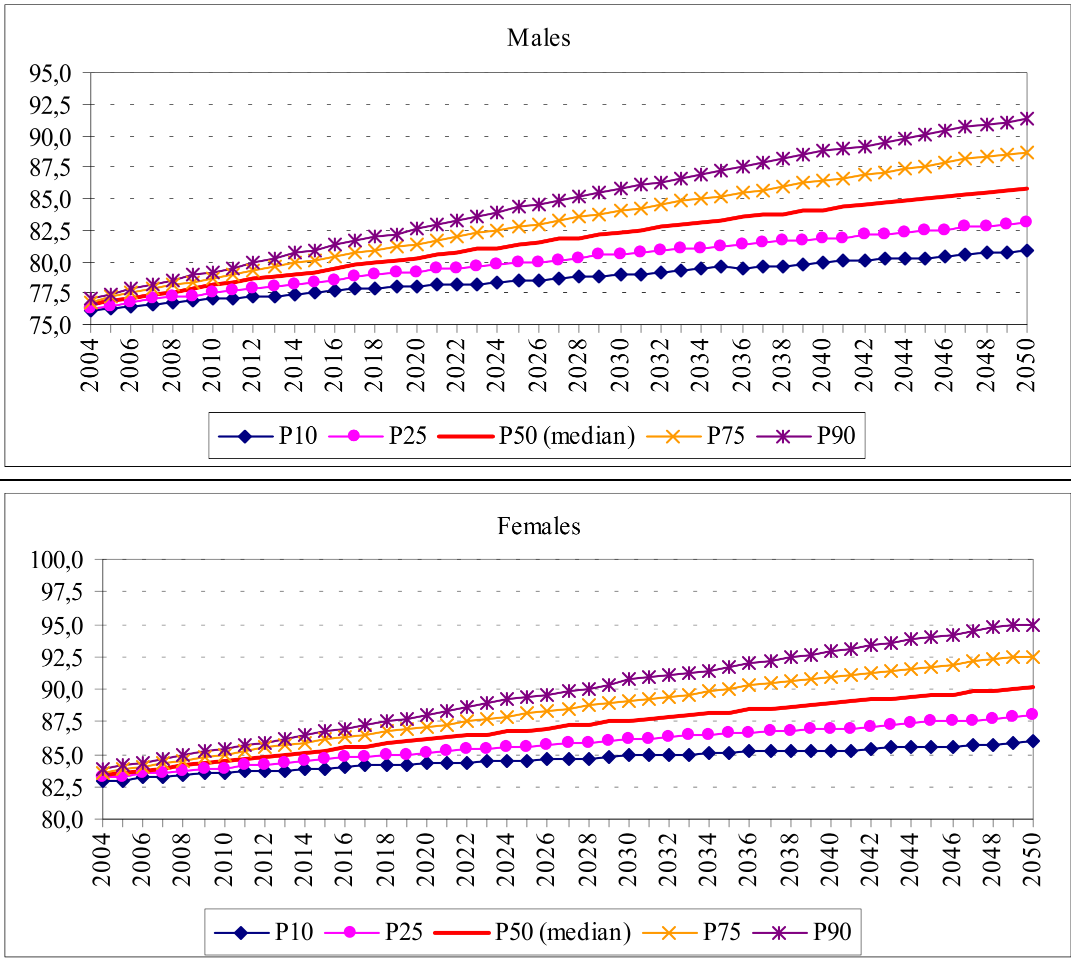


Note: the aged dependency ratio is the number of persons aged 65 and more over those aged between 15 and 64.

Life expectancy

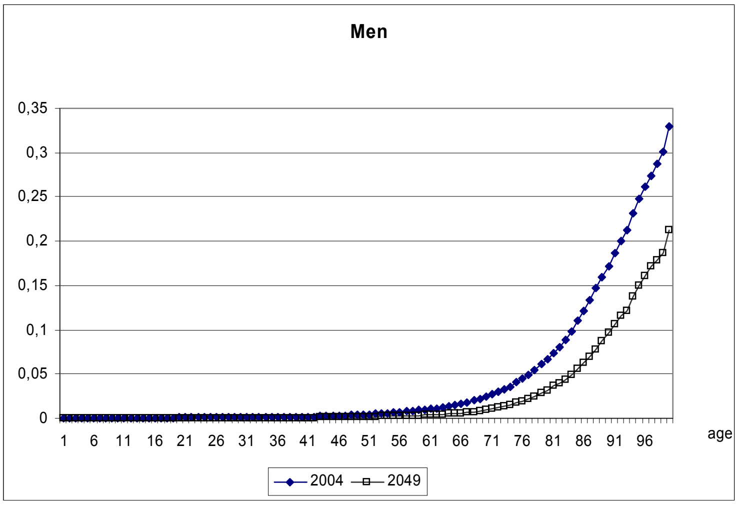
As for life expectancy, and thus mortality, the results of the stochastic simulations are offered separately for men and women in Graph 8 together with a number of selected percentiles that help to ascertain the probability intervals of the simulations. The median projection shows that the life expectancy at birth will increase from 76.6 to 86 for men and 83.4 to 90 by 2050. It can be seen that with a 10% probability life expectancy at birth will be higher than 91 years for men and 95 for women by 2050. The general pattern is that life expectancy will increase almost linearly in the future.

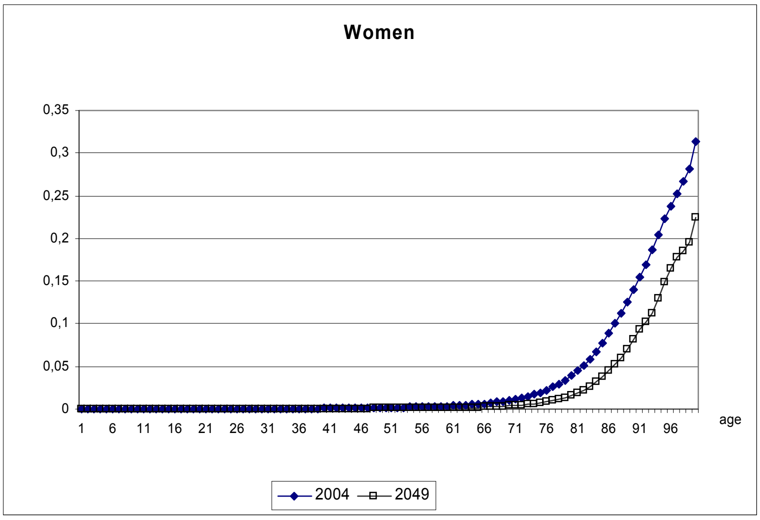
Graph 8
Projected median life expectancies at birth for Spanish male and female and probability intervals for 50% (P25 to P75) and 80% (P10 to P90)



The increasing life expectancy at birth is obviously due to the accumulation of improving age-specific mortality rate. Graph 9 shows the changes in mortality rates for men and women during the projection period (2004-2049) according to the median projection. Although it is not graphically distinguishable at young ages, the improvement in proportion is larger in younger ages. For example, the male mortality rate up to age 40 in 2049 decreases to a level lower than 30% of that in 2004. At ages around 80 the reduction in the mortality rate is about 50% during the same period. For females the improvement is a little smaller. For example, the female mortality rate in 2049 at age 40 is 43% of that in 2004, and at ages around 80 the mortality rate reduction is about 40%. This gender difference results in some narrowing over time in mortality rate by gender as also shown in life expectancy graphs.

Graph 9
Median projection mortality rates in 2004 and 2050





6. Stochastic Health Expenditure Projection 2004-2050

The above result concerning population projections for Spain have shown that accelerated ageing is not only a likely outcome for the evolution of Spanish population, but that this ageing process could take some extreme shapes with a non-negligible probability. One of the most analyzed likely economic consequences of ageing is health expenditure. Welfare programs in general are highly sensitive to the aggregate dependency ratios as long as they rely on pay-as-you or general taxes financing the benefits for the elderly. In the case of health expenditure, the novelty that stochastic population projections bring in is that they provide us probabilistic distributions of health expenditure in the future, therefore enabling us to assess the probability and the magnitude of the problems in the future concerning health expenditure.

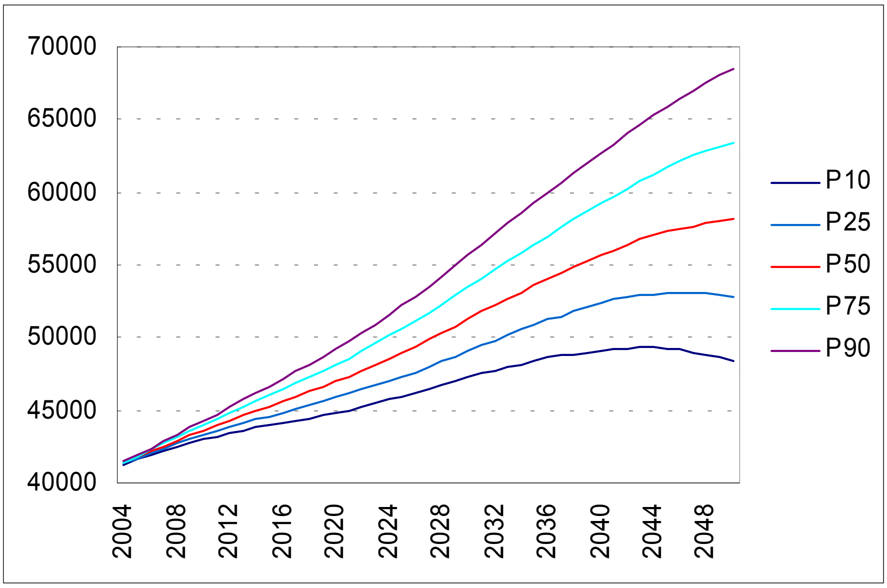
In this section, we apply the stochastic population projections discussed above to the case of public health care expenditure in Spain from 2004 to 2050.

In particular, for the case of hospital costs we discuss the consequences of not taking into account the costs-to-death at different ages. This is important given the substantial improvement in life expectancy shown earlier. For the case of maternity cost, we do not consider them since its effect is almost negligible since the impact of maternity cost on total health care expenditure and the proportion giving birth are rather small as shown in section 4.

6.1. Total public health expenditure

Combining age-specific per-capita public health expenditure (graph 1 in section 3) with stochastic population projections (section 5) we obtain stochastic public health expenditure. As we use 1500 simulated population each future year, we obtain 1500 total health expenditure corresponding to each population simulation. A convenient summary measure of the health expenditure distribution is percentile. Graph 9 shows the projection results of the median and various percentiles of total public health expenditure. The total health expenditure obviously will depend on the total population and its age structure: the larger and the older the population, the greater will be the health expenditure. Therefore, higher percentiles of expenditure represent larger and older populations and vice versa. By 50% probability the total expenditure lies between 53,000 and 63,000 million euros. By 80% probability it lies between 48,000 and 69,000 million euros.

Graph 10
Total public health expenditure (million euros)

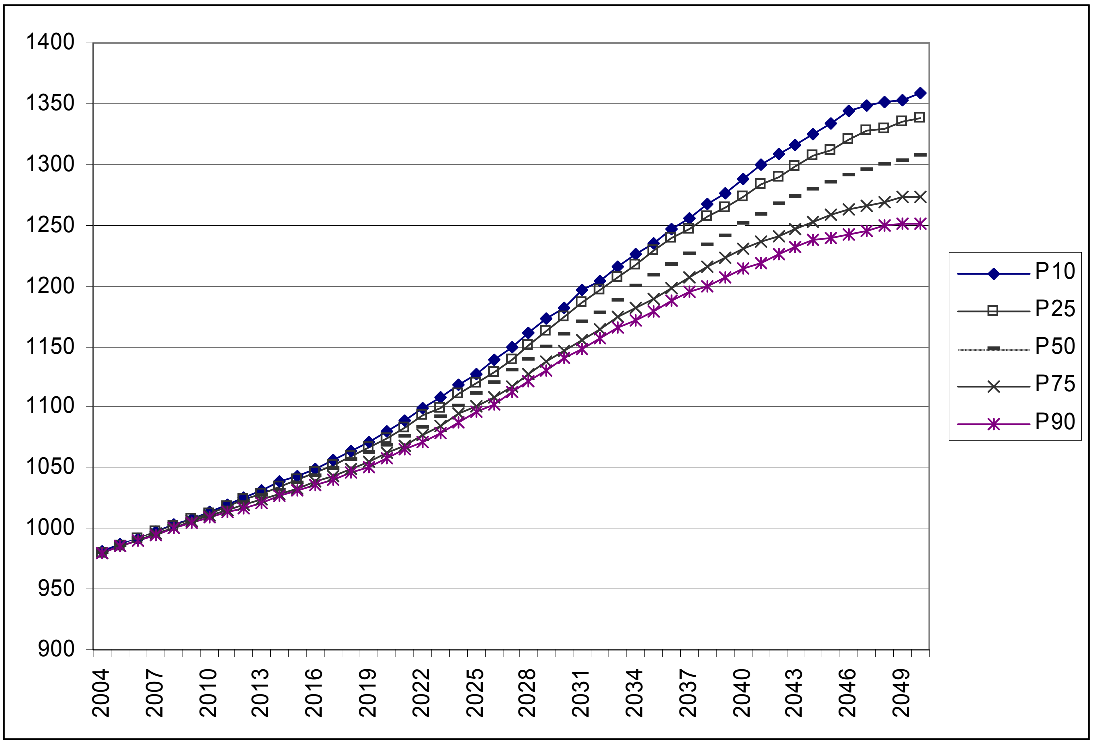


The median projection shows that public health expenditure will increase by about 40% during the next 47 years, from a little over 40,000 million euros in 2003 to 58,000 million euros by 2050. This corresponds to an annual increase of 0.74%. There is a 10% chance that the expenditure will increase to a level higher than 68,500 million euros (66% increase from 2003 to 2050), which corresponds to an annual increase of 1.1%. The optimistic side shows that by a 10% chance we will face the total expenditure lower than 48,500 million euros (only 17% increase) in 2050 corresponding to an annual increase of 0.35%.

Since the population in the median projection changes only by a little more than 2 millions (or by only 5%), the main part of the increase in total expenditure is driven by the increase in average per-capita expenditure due to ageing. Graph 10 shows the per-capita public health expenditure according to the median and various percentile population projections. The median projection average per-capita expenditure increases by 33%, from 980 in 2004 to 1307 euros in 2050. This shows clearly the importance of ageing in the health expenditure. If we assume that real per-capita public health expenditure increases by the same rate as per-capita GDP, the share of the public health expenditure in GDP will increase from 5% today to 6.7% in 2050. Again, we should remember that this increase is solely due to the change in demographic situation without considering other factors relevant to health expenditure.

Two other things to notice in per-capita expenditure. First, the size of per-capita expenditure is reversed in order from the total population size. That is, the greater the total population, the smaller the per-capita expenditure. This indicates that in our simulation larger populations are younger in average age. Second, the dispersion is smaller than in total health expenditure. For example, in 2050 the 80% probability interval ranges from 1251 to 1359, or 9% variation, in per-capita expenditure while the same interval in total health expenditure ranges from 48,500 millions to 68,500 millions, or 41% variation.

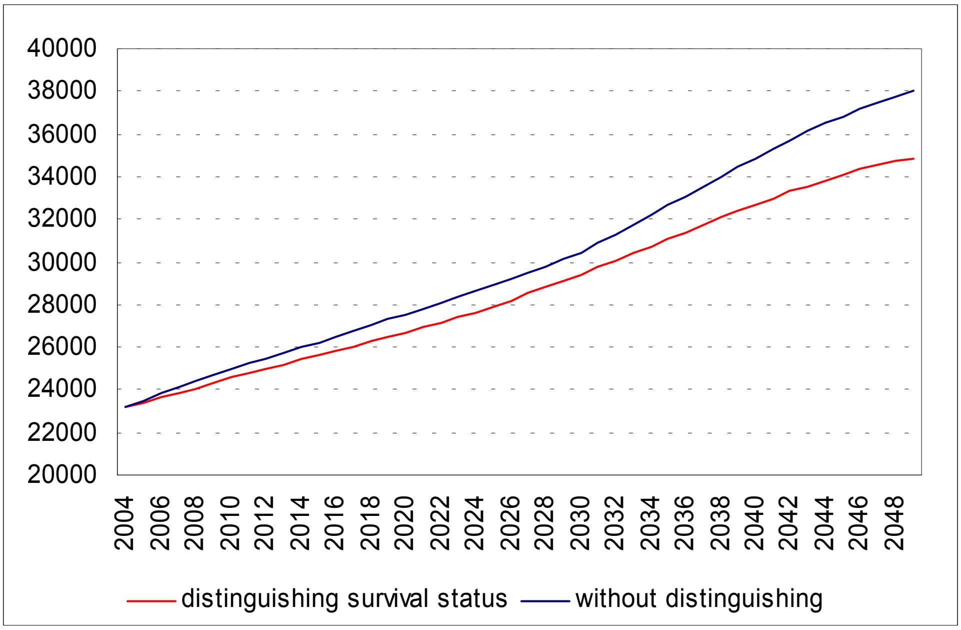
Graph 11
Per-capita public health expenditure (euros)



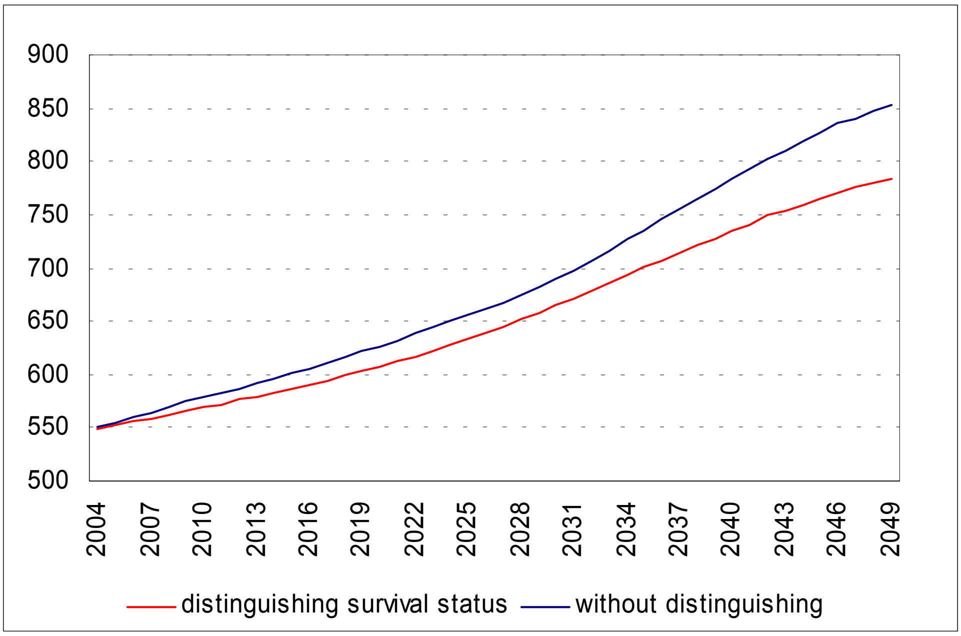
6.2. Hospital expenditure

For the hospital expenditure, as we explained in the section 3, we can distinguish the expenditure for survivors and decedents. We can separate the population by survival status up to 2049 as we do not know their survival status for the last year of projected population. As the population projection assumes substantial improvement in the mortality rate over the projection period as shown in the previous section, the consideration of survival status is important in the projection of hospital costs. Combining the age-specific per-capita hospital expenditure by survival status as shown in section 3 (Graph 3) with the population projection by survival status, we obtain the hospital expenditure projection. Graphs 11 and 12 show respectively the median projection total and per-capita hospital expenditure both distinguishing and without distinguishing survival status.

Graph 12
Median projection of total public hospital expenditure



Graph 13
Median projection of per-capita hospital expenditure



As the mortality rate decreases in the future, the hospital expenditure when we distinguish survival status is lower than when we do not distinguish it. The difference in the projected hospital expenditure by survival status distinction increases over time as the mortality decreases continuously over time. The reduction when we distinguish relative to when we do not distinguish amounts to about 4 percent by 2025 and 8 percent by 2049. Total hospital expenditure will increase between 2004 and 2049 by 55% without distinguishing compared to a 43% increase with distinction. If we compute annual change, it amounts to 0.98% without and 0.79% with distinction. This difference (0.2% annual) is not trivial but neither too large.

7. Concluding comments

One of the areas where aging will be particularly relevant is health care expenditure as per-capita health spending increases rapidly with age. For example, in Spain, a person over 75 years causes almost 7 times more public health expenditure than a person aged 6-20. Increasing health spending with age accompanied by population aging implies an increasing aggregate health expenditure in the future, even when other factors remain constant.

Previous projections of health expenditure have been usually carried out by combining a constant (over time) age-sex specific health expenditure with deterministic scenario-based population projection. However, it has been shown repeatedly that both age-sex specific health expenditures and the population structures in the future are highly uncertain and most projections turned out wrong. Therefore, the projections based on the traditional approach are often unhelpful in evaluating future health care expenditures. In this project we try to improve upon the existing literature by incorporating uncertainties in population projection and future age-sex specific health expenditure.

Stochastic population projections for Spain have shown that accelerated ageing is not only a likely outcome for the evolution of Spanish population, but that this ageing process could take some extreme shapes with a non-negligible probability. For example, by 50% probability the aged dependency ratio will increase from 0.25 now to a level higher than 0.67 by 2050. Even looked at from the most optimistic side, the chance that the ratio lying below 0.54 is mere 10%. That is, the age dependency ratio will be higher than 0.54 in 2050 by the probability 90%.

Combining the stochastic population projection with age-specific health expenditure we obtain stochastic health expenditure projection. The novelty that stochastic population projections bring in is that they provide us probabilistic distributions of health expenditure in the future, therefore enabling us to assess the probability and the magnitude of the problems in the future concerning health expenditure.

The median projection shows that public health expenditure will increase by about 40% during the next 47 years, that is, an average annual increase of 0.74%. There is a 10% chance that the expenditure will increase by more than 66% during the projection period, which corresponds to an annual increase of 1.1%. At the optimistic side the total public health expenditure will grow only by 17% (0.35% annual) with a 10% probability. Since the population in the median projection changes only by 5% during the period, the main part of the increase in total expenditure is driven by the increase in average per-capita expenditure due to ageing. The average per-capita expenditure increases by 33%, from 980 in 2004 to 1307 euros in 2050. This shows clearly the importance of ageing in the health expenditure. If we assume that real per-capita public health expenditure increases by the same rate as per-capita GDP, the share of the public health expenditure in GDP will increase from 5% today to 6.7% in 2050, solely due to demographic change.

One factor that could reduce the expenditure pressure in the future is that with decreasing mortality rate there will be fewer people in their last year of life combined with the fact that a major part of health expenditure is driven by decedents. We could distinguish survival status only in hospital costs using DRG data. Our estimation suggests that distinguishing hospital costs by survival status could reduce somewhat (by about 8%) total hospital expenditure in 2049. However, one thing that we have to keep in mind is that we have used constant age-specific per-capita health expenditure by survival status. It is not known if the increases in longevity is due to a prolongation of life in bad health or in good health (expansion vs. compression of morbidity) which will affect age profiles of health expenditure for both survivors and decedents. The final effect of mortality decline on age-profiles of health expenditure will depend on the relative importance of all these factors. Confounding the problem more is the observation that declines in mortality among the elderly are partially due to the increasing per-capita health expenditures which provide more and better health care services. Therefore, one has to consider this causality in projecting future health expenditure if decreasing mortality rates are assumed in their underlying demographic projection.

In this paper, an important step is taken in health expenditure projections as we incorporate demographic uncertainty. However, future health care expenditure also depends on other uncertain factors, such as price (technology and preferences), health status and health service usage rate in the future. Uncertainties of all these elements are much harder to deal with than demographic uncertainty, the reason why we concentrated on demographic uncertainty in this paper. In fact, technology is intrinsically unpredictable as it refers to the discovery of unknown things or new ways of doing things. Predicting the health status and health behavior in the future is an equally difficult task, partly because they depend on future price. The natural first step in the approach to learn about the likely future health status and health behavior is to understand the past trend. In a complementary paper we study the evolution of past health status and their determinants which will help us say something about the likely health status in the future.

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