Please note, this is not a paper yet but a preliminary draft of a paper. The final version will get a technical appendix, we will add confidence intervalls to our forecasts and the text, the reference list as well as the English will be polished. It is work in progress. Further suggestions for improvement are highly appreciated.

The Cost of Population Aging

Forecasting Future Hospital Expenses in Germany

Hilke Brockmann & Jutta Gampe

I. Introduction

Population aging is not a new phenomenon. Since the first half of the 19th century, life expectancy has increased at all ages in the modern world, since 1950 primarily among the oldest-old (see i.e. Vaupel et al. 1998; Gjonca, Brockmann, Maier 2000;Oeppen, Vaupel 2002). What is new, is that population aging has become a hot political topic. The reason lies in the chronic fiscal problems of the welfare state. The welfare state throughout the OECD-world is “first of all a welfare state for the elderly” (Guillemard 1983, 3). If it is under fiscal stress now, that the baby boomers are still in work, how will it fare later once they retire?

Most forecasts predict an impending cost explosion in public pensions and the health care system. For this reason Friedrich Breyer, a German health economists, recently suggested the introduction of rigid age limits in the future. German public health insurance funds should stop to pay for costly and life-sustaining health treatments for people of 75 years and older (Report Mainz 2003; Breyer 2002; Breyer and Schultheiss 2003). Before implementing such draconian measures, we should be confident that health care costs will in fact explode. In this paper, we contend that they may not: there is reason to believe that the effect of population aging on health care costs will be more muted than is commonly assumed.

In order to gauge the effect of population aging on health care expenditure, we have to check how it interacts with the two main drivers of health care costs: health care utilization and medical progress (Getzen 1992; Cutler, Sheiner 1998; Breyer, Ulrich 2000; Blumenthal 2001; Freund, Smeeding 2002).

Does population aging drive up the rate of health care use? Or how healthy will the future elderly be? Most forecast scenarios based on deterministic assumptions seriously underestimate the life expectancy and health of the elderly in advanced western societies (Vaupel, Oeppen 2002; Tuljapurkar, Li, Boe 2000; Robine, Mormiche, Sermet 1998; Doblhammer, Kytir 2001). In contrast, we exploit empirical information to project future health care needs. Our probabilistic forecast is based on probabilistic health estimates derived from historical data on mortality and hospital use.

Does medical progress magnify or mollify the burden of future health care costs? Are older patients disproportionately benefiting from medical progress? Although it is now a standard to assume that technological expenses grow at a higher rate than GDP (Lee, Miller 2001; Technical Review Panel 2000), more recent studies on single medical technologies cast doubt on this assumption. As they demonstrate medical progress may actually reduce treatment costs on a per unit level (Cutler, McClellan 2001) and on the overall level when quality is accounted for (Cutler, McClellan, Newhouse, Remmler 1998). We address these findings by including quality measures of medical outcomes in our projections. We focus specifically on hospital costs since hospitals make use of the most progressive medical technology. Also, hospital expenditures are the highest single expenditure item in health care spending. Finally, hospital treatments usually imply comparatively low moral hazard since patients have little interest in overusing hospital services.

Our forecast yields three important results. First, there is an increase in overall hospital care expenditures until 2040 to 2050. Second, this increase is comparably moderate, average individual costs are likely to decline, because the health of the elderly improves and medical progress has an ambiguous impact on hospital expenditures. Finally, the cost increase varies significantly by gender and disease. The remainder of the paper is organized in five sections. Section II provides background on health care forecasts. Section III discusses our empirical methodology. Section IV presents our results, and Section VI concludes.

II. Background or how to link demography with medical progress?

1. Forecasts with cross-sectional data

Since public health care is mostly financed on a pay-as-you-go basis, many studies and official forecasts extrapolate from aggregated annual expenses to future health care costs (Espenshade, Braun 1983; Prognos 1998, Mayhew 2000, 2001; Board of Trustees 2000). This cross-sectional approach is straightforward and gives priority to demography. Basically, age-specific yearly expenditures are weighted by the proportional size of the age group in the total population. Population aging is introduced by changing the age weights in line with demographic forecasts. Medical technology and factor costs are - implicitly or explicitly – growing at the same rate as the total economy. As a consequence, health care budgets must increase as the number of elderly people increases (Waldo et al. 1991; Warshawsky 1994). Based on this design, Knappe (1995), for example, calculated that the contribution rates to German health insurance funds have to rise from on average about 13.5% in 2000 to 25 % of wages by 2040.

2. Forecasts with time-series data

Getzen (1992, 99) criticizes age-group projections for just offering „what if" predictions of hypothetical demographic effects while ignoring the empirical dynamics of population aging and medical progress over time. In order to reflect longitudinal trends, he regresses the percentage of people over 65 years, growth rates in GDP and a trend variable on health care spending of 20 OECD countries for the years 1960 to 1988. He finds that population aging is associated with health care spending only if all other variables are left aside. Including per capita income and a time trend absorbs the age effect completely. In fact, countries with a relatively old population like Denmark or Norway are neither more nor less likely to have higher health care expenses.

Country specific studies, by contrast, often find a significant but minor effect of population aging on health expenditure. Newhouse (1992) estimates for the United States that increases in technical sophistication of medicine account already for more than 50% of rising medical costs. The impact of older population, increased income, and more generous coverage is much weaker.

Breyer and Ulrich (2000) regress real income of insured members as a proxy for productivity and process innovation, calendar years as an indicator for medical progress, and the proportion of insured members over 65 years on the expenditure increase of

Germany‘s compulsory sickness funds during 1970 to 1995. This regression equation explains more than 98 % of the variance and shows that technological progress increases health expenditures by an additional 1 % each year while an increase in the elderly population by 1 % raises the per capita expenses significantly by 8 %. Fitting these regression results into an official population projection scenario lead to an increase in health insurance contribution from about 13 to 16 % in 2000 to 23.1% in 2040.

3. Forecasts with life-cycle data

However, recent individual level and cohort studies raise doubts about the predictive value of deterministic demographic scenarios and aggregate economic trends. Tracing individuals over their life-cycle shows that proximity to death rather than chronological age determines the left-skewed distribution of health care costs over lifetime (Turnbull et al. 1979; Schroeder et al. 1981; Scitovsky 1984; 1988; Zweifel, Felder, Meier 1999; Yang, Norton, Stearns 2003). This schedule of health care expenditures seems to be stable over time (Lubitz, Riley 1993; Garber, MaCurdy, McClellan 1998). What is more, health care expenditures during the last years of life increase less among older and oldest-old than among younger people (Lubitz, Beebe, Baker 1995; Brockmann 2002; Felder, Meier, Schmitt 2000). This may suggest that an aging population may cause a less pronounced rise in health care expenditure than is commonly assumed.

Miller and Lee (Miller 2000; Lee, Miller 2001) translate life-course expenses into national forecasts of medicare expenditures. In contrast to age group projections, they use average medicare costs by time-until-death and weight these expenses with the percent distribution of time-until-death years in future populations. The mean and the entire distribution of time-until-death for individuals being at certain age are obtained from cohort life tables. Official forecasts as well as alternative time series are used to project future US mortality rates. Generally, the time-until-death approach forecast lower medicare expenditures than a simple age-group projection. Even though official forecasts may systematically under-project mortality declines and gains in life expectancy, Miller still makes out a difference in medicare expenses of 14% between both approaches in 2070 based on official data (Miller 2000, 10). In addition, simulating probabilistic mortality forecasts based on historical data reveals diverging expenditure patterns after the year 2015 when the American baby boomers enter medicare. Before that date, longevity does not incur rising health care costs. Long-term projections show, however, that increasing longevity triggers a transition from a short-term decline in medicare expenditures to a later increase due to the growth in numbers of elderly.

4. Technological life-cycles

A major shortcoming of Miller's paper (2000) is the neglect of technological change. Even if empirical proof is rare and national variation high, it is generally agreed that technological change is a major cost driver in health care (Cutler 2003; Blumenthal 2001; Mohr 2001; Okunade, Murthy 2002, Zweifel, Manning 2000). In a later paper Lee and Miller add the mean growth rate from the Medicare Trustees Technical Report to their projection but admit that in this way they have „out-sourced the single most important component of our forecast“ (Lee, Miller 2001, 7). This is even more unfortunate since a life-cycle approach turns out to be a useful tool to also understand the linkage between medical progress and health care costs.

Thomas (1975) and Weisbrod (1991) have traced the cost profile of medical technology over the technology life-cycle. At an early stage in the life-cycle of a technology, when not much is known about the disease, therapy is palliative and cheap. ALS (Amyotrophic Lateral Sclerosis) is an example for this early stage of a medical technology. A second stage is achieved when "halfway technologies" can treat symptoms. An example would be cancer measures that fight already established cancer cells but not the actual cause „by which cells become neoplastic" (Thomas 1975, 39; Weisbrod 1991, 533). These therapies are very cost-intensive, because they keep the disease chronic. At the end of the life-cycle therapies are based on a genuine understanding of disease mechanisms and cure patients at low costs. Many infectious diseases are at this stage. Vaccination may even lead to the extinction of the disease.

Pardes et al. (1999, 36) pick up on the life-cycle idea and speculate that understanding human biology at the molecular level may replace costly invasive surgery, intensive care-units or long-term nursing home care by preventive and tailor-made gene therapies or by less expensive genetically engineered pharmaceuticals.

Studies on the development and productivity of the treatment of coronary heart diseases provide further empirical evidence for this approach. Cutler and Huckman (2003) traced the diffusion of percutaneous transluminal coronary angioplasty (PTCA), a procedure that is less invasive and a possible substitute for coronary artery bypass graft (CABG) surgery. Although the per unit cost of PTCA are lower than for CABG, the overall costs increased due to an expansion of the therapy to less severely diseased patients. Over decades, however, this increase levelled off when PTCA was more and more substituting CABG and caused lower costs with the same or even better outcome.

Also, it does not seem an iron law that medical technology increases health care use and health care costs. Medical care decisions are either made by patients who are not insured at the margin and who are liable to moral hazard or by medical care providers who have an incentive to use more technologies and whose interests may not coincide with those of the patients. Thus health care utilisation does not necessarily reflect a real demand for medical care. In addition, new medical technologies do not inevitably mirror a real quality change in medical care. To consider quality change, Cutler, McClellan, Newhouse, and Remler (1998, 993)(Cutler, McClellan et al. 1998) formed a new price index that measures how much consumers would be willing to pay or would have to be compensated to accept quality changes in medical treatments and prices over time. They estimate that for heart attack treatment this price index fell about 1 % annually showing that advancing technologies do not necessarily forces prices up.

To sum up, life-cycle studies suggest that technological change and population aging may not necessarily increase health care expenditures. In predicting future health care costs, it is imperative, therefore, to account for these dynamics of technological development and individual health trajectories.

III. Data and Methods

1. Data

Our forecast model draws on three different data sources. First, we use the Human Mortality Database (HMD) for the years 1956 to 1999 to forecast future mortality and future population size. The HMD provides population data for both sexes, for single-year age groups, and single period years. The ages 95 and older have been collapsed to attenuate large fluctuations due to small sample sizes.

The second source are individual level hospital expenditures, which are based on hospital claim files from Germany's largest public health insurer. We use data from the regional fund of Westphalia-Lippe (West Germany), which had 480,329 members who were 65 years and older. Westphalia-Lippe provides a representative sample of Germany and 65 years is the compulsory retirement age. Individual health-care costs were summed up when they occurred during the previous 365 days before the date of last discharge in 1997. If a hospital stay extended beyond this period, we accounted only for those days that fell within the defined individual year and calculated mean daily costs.

Finally, we used official hospital data from 1993 to 1999 (Krankenhausstatistik 2003).

2. Models & Measures

We model the main determinants of future health-care expenses – the number of elderly, their health status, and progress in medical treatment –separately in order to study their individual impact on aggregate outcomes. Moreover since predictions are inherently uncertain, we also take this uncertainty into account. Our model comprises a stochastic demographic component, that exploits historical mortality trends, a stochastic cost component based on life-course typical hospital costs, and a quality measure of medical progress, which builds on past advances in hospital treatment. Based on these models different scenarios will be simulated.

2.1. Demographic Forecasts

Official population forecasts have been criticized by a growing group of demographers, whoexpect longer lives for future populations and propose a stochastic model, which adds on historical trends (Vaupel, Oeppen 2002; Lee, Miller 2001; Tuljapurkar, Li, Boe 2000; Keilman 1998). Lee and Carter (1992) introduced a model for mortality forecasts which since then has been applied to data from several developed countries (Tuljapurkar, Li, Boe 2000; Booth, Smith, Maindonald, 2002). Recently, Lee and Miller (2001) re-evaluated the performance of the Lee-Carter model and gave a thorough discussion of its merits and shortcomings (see also Lee, 2000). In a first step, the Lee-Carter model extracts the first principal component from a series of log death-rates (Lee,Carter 1992; Bell, 1997). In a second step, the resulting time-series of this principal component is fitted and predicted by standard ARIMA techniques (Brockwell, Davis 1991). Applicability of this approach for German mortality data has been tested (Gampe, Brockmann 2003).

We use West German mortality forecasts based on the period 1970 to 1999 to predict the number of males and females by single year of age from 65 to 94 and an aggregate age group for 95 years and older. The prediction period was 65 years. Furthermore, the number of people surviving one year of age and those dying during the year were determined. This distinction is necessary to appropriately assign hospital costs (see next section).

2.2. Individual Hospital Costs

Individual costs (on a log-scale) were estimated to be a linear function of the length of stay (also on log-scale), a quadratic function of age, and an ICD-specific intercept. Separate models were estimated for surviving and deceased men and women. Regression diagnostics suggests excluding patients whose expenses amounted to less than 500 DM (2.9 %). The majority of these cases do not represent real hospital cases, but arise from false admission, misreporting, incorrect billing, or missing data. Since underreporting is not in the interest of hospitals and over-reporting is not in the interest of the insurer, the remaining data are fairly reliable.

Figure 1 about here

Figure 1 shows the age-specific proportions of the most frequent causes of death in old age, which vary over age, among diseases and deceased and non-deceased patients. Moreover, group-specific incidences were estimated from the total number of insured persons by age, sex and survival status. Figure 2 displays hospital expenses by age for selected groups.

Figure 2 about here

2.3. The Quality of Technological Progress

Although medical progress is identified as a major cost-driver, its measurement is far from being standardized. Aggregate growth rates are often used, but the level of growth varies considerably. Moreover, aggregate measures are affected by perverse effects such as moral hazard or supplier-induced demand and do not reflect quality changes in medical progress. We therefore apply indicators of medical advancement that focus on the patient's utility. Medical progress has two preferred outcomes. Firstly, it should make treatments more efficient and compress the time of morbidity. Secondly, progress should expand the range of possible treatments so that in the future, less people will suffer from today's diseases. These two outcomes are reflected in two measures: the length of hospital stay and the range of medical therapies. Although we cannot guarantee that these measures are not contaminated by perverse effects, we are sure that the probability and the length of a hospital stay is less distored than any aggregate measures like hospital growth rates since it is a direct infringements of patient's rights and interests.

We make use of official statistics that cover the decline of the length of hospital stay over time. During the early 1960s patients stayed on average more than 28 days in a hospital or a rehabilitation clinic. Since 1991 hospital stays are separately recorded and patients spent then on average 14.3 days in a West German hospital. Ten years later a mean hospital stay lasts 9.8 days (Statistisches Bundesamt 2003, Fachserie 12). Since 1993, the length of hospital stay is further broken down by age groups and ICD classes (Krankenhausdiagnosestatistik 2003). In order to exploit these detailed information, we calculate the mean decline of length of stay per year, age group and ICD class and weight simulated future hospital stays down by this factor. Since individual level data show a significant and systematic decline in length of hospital stays by age, we further add an age-adjusted length of stay to the analysis.

Medical progress also improves the possibilities to treat more and more diseases. The expansion of medical interventions express rising numbers of total hospital days per 10,000 inhabitants. Official statistics show that these numbers are rising although at different rates in different age and disease groups (Krankenhausdiagnosestatistik 2003). We derive age and disease-specific mean growth rates and weight simulated future utilization rates up.

2.4. Scenarios

We draw 3 scenarios in which we stepwise relax assumptions. The first scenario focuses on the effect of population aging and holds all other influences constant. In the second scenario we let the people have a longer and healthier life. That is, we assume that a higher life-expectancy is accompanied by a slow but steady shift in age-specific disease incidence proportions towards higher ages. The third scenario introduces medical progress by shortening the length of stay according to the yearly decline rates and by taking the increasing number of future hospital cases into account. Individual-level data also shows that younger patients stay significantly longer in hospitals than the oldest old (for explanations see Brockmann 2002), we therefore also add an age-adjusted length of stay. All scenarios will be broken down by sex, and major ICD classes (ICD2 cancer, ICD7 diseases of the circulatory system, ICD8 diseases of the respiratory system and ICD17 accidents, injuries, and poisonings).

IV. Forecasting Future Hospital Costs

1. Scenario one: Population aging or what will the growing number of older men and women cost?

Population aging means first of all that the number of older people will increase. If we only project this trend we observe a steady increase in overall hospital expenditures from about 24.7 billion Euros up to more than 46 billion constant Euros in 2041. When the German baby-boomers born in the 1960s will die out during later years, hospital expenses will drop again. In 2065, hospital costs will be nearly 39 billion Euros or 157% of the expenditures in 2000.

Our forecast reveals stark gender differences. During the whole projection period, women's total hospital treatment will cost more than men's treatment. In 2000, hospital expenses for older women were 7.8 billion Euros higher than for older men and summed up to 28.1 billion Euros. The gender gap is shrinking to 800 million Euros in 2038 and although this difference increases during later years it will remain below 50% of the current amount.

In terms of relative costs, however, the gender gap is widening as hospital expenses for men will increase at a higher rate than for women. Outlays for men will be nearly 2.2 times higher in 2040 than in 2000. For women, expenses reach a peak in 2043 at 1.6 times the expenses of 2000. After that both expenditure curves decline although less steeply than they rose. The gender gap remains. The unequal mortality regimes of men and women translate into different hospital expenditure profiles at old age.

Figure 3 about here

Different diseases contribute differently to the overall trend. The major killer ICD 7 is the single most expensive disease class. In 2000, hospital treatments added up to more than 3.6 billion Euros for older women who suffered from diseases of the circulatory system and more than 3.2 billion Euros for older men. During the following years the treatment for men, however, will become more expensive than for women and will peak in 2039 at 7.1 billion Euros. Hospital expenses for women will be highest in 2042 with 5.9 billion Euros. In comparison, the relative increase of hospital expenditures for cancer, the second most frequent cause of death, will be lower. But for the treatment of accidents, injuries and poisoning it will be higher and will go up to 240% for men in 2047 and 199% for women in 2051.

Decomposing these figures by the number of future beneficiaries reveals a different outlook on future hospital expenditures. The average hospital costs for a cancer patient will decline steadily during the period of observation. In 2064 expenses will be 23 % lower for women and 16 % lower for men than in 2000. In comparison, we project no time trend for the average expenses of diseases of the circulatory system and of the respiratory system. These outlays will range around the expenses of the year 2000. Expenses vary between +/-3.8% (ICD 7) or +8.6 % and -5.3 % (ICD 8) for women and +1.1% and –2.5% (ICD 7) or +7.9% and –3.6% (ICD 8) for men. However, hospital expenditures for treating accidents and injuries will increase and peak at 130% of women’s hospital expenditures of 2000 and 122% of men’s hospital expenditures in 2057.

Figure 4 about here

Generally, average expenses per beneficiary do neither replicate the route of the total expenditure curves nor reveal any continuous and substantial increase in future hospital outlays. On the contrary, average expenses vary only moderately. This first scenario is, however, still quite unrealistic, as we assume that the future elderly will be as healthy as today's 65 year old and older population. This assumption will be relaxed in the next scenario.

2. Scenario two: Population aging of healthier elderly or how much pay health improvements?

There is general agreement among demographers that people will live longer because they are healthier. The only disagreement is about precisely, how much their health will improve. Oeppen and Vaupel (2002) show that female life expectancy in the record-holding country has risen for 160 years at a steady pace of almost 3 month per year. To be on the safe side we rejuvenate the age and ICD-specific incidence rates by 0.1 year annually, meaning that in 10 years time a 66-year-old will have the same health status like a 65-year-old today.

Figure 5 about here

Given these health improvements, we observe lower hospital expenses than in the first scenario throughout the whole projection period. For men, the expenses are up to 2.2

billion Euros or 21 % less around 2042 and 2065 than in the previous forecast. For women, the difference sums up to 2.5 billion Euros or 17% during the same years. In absolute numbers, the gender gap shrinks and disappears for a couple of years around 2035. In relative numbers, the gender gap will first grow and stay large after 2035. Men's hospital expenditures grow stronger until 2040, while women's hospital expenses turn out to be less health sensitive.

Figure 6 about here

A healthier older population will also need less money for the hospital treatment of the major killers in old age. Per capita expenses for cancer, diseases of the circulatory or respiratory system as well as for accidents, poisonings and injuries will drop substantially (up to 20%) below their level in 2000. Compared to the first scenario, hospital expenses for women with ICD 17 decline with 38 % most strongly. Only cancer treatments for women, which will also decline over time are slightly higher in this second scenario than in the first one.

3. Scenario three: Population aging, health improvements, and medical progress or how much does medical progress add to the bill?

The demand of hospital care depends on the supply. Medical progress will decisively determine the development of health care demand and health care expenditures. The ICD- and age-specific decline in the length of hospital stay during the last years is our first indicator of medical progress. Figure 7 illustrates this dominiating effect. Hospital expenses would drop up to 90% given this assumption. Obviously, this is not a realistic scenario and we therefore display only some representative examples. However, these examples illustrate the saving potential of medical progress, given it would exclusively focus on increasing the efficiency of today's hospital treatments.

Figure 7 about here

Improving the efficiency of current therapies is one aim of medical progress. The other is the search for effective new treatments. We measure this advancement by the increasing number of hospital treatments per inhabitants over time. If we project these ICD- and age-specific rates into the future in addition to our previous assumptions, hospital expenditures will not shrink but increase. Compared to the first and second scenario, however, the expenses will be lower during the first decades, precisely until 2034 rsp. 2039 for women and 2049 rsp. 2013 for men in the first two settings. During later years medical progress will lead to higher expenses. This applies particularly for men whose hospital expenses will rise more steeply than for women, so that from 2022 onwards their hospital expenses will be higher than outlays for women for the first time in our forecasts. We also project that total expenditures will peak by 23 billion Euros for women and 26 billion Euros later than in the previous scenarios, precisely in 2050.

Figure 8 about here

These absolute numbers translate into a widening gap between the future expenses for men and women compared to their outlays in 2000. Hospital expenditures for older women will rise by 60% until 2050, while men's expenses will be 150% higher than in 2000.

Figure 9 about here

Disease-specific expenditure profiles show that medical progress leads in most of the cases and for the two major killer, diseases of the circulatory system and cancer, to substantially lower expenses for women and higher expenses for men. An exception are diseases of the respiratory system. Here outlays for women will multiply by four in 2065, while hospital costs for men will increase by 124% at the same time.

It is beyond the scope of the paper to explain why men benefit more from medical progress than women. We can only speculate here, but there is some plausability that agism and sexism (Brockmann 2002) may lead to an unequal expenditure profile. Also changing life styles like the increasing number of smoking women will likely determine future expenditures for the treatment of diseases of the respiratory system (Caselli 1996). Future research has to analyze these relationsships, for our projection we have to take them as given.

V. Discussion

Forecasts are always wrong. Still, forecasts show future possibilities and give reasons for policy decisions today. Deterministic forecasts are based on the author's assumptions and project high, medium and low scenarios that by definition vary strongly. Probabilistic projections, on the contrary, control for the likelihood of future outcomes by exploiting past empirical trends. In this paper, we used a probabilistic forecast model and the empirical findings of life-cycle spending to project the future effects of population aging on hospital expenditures.

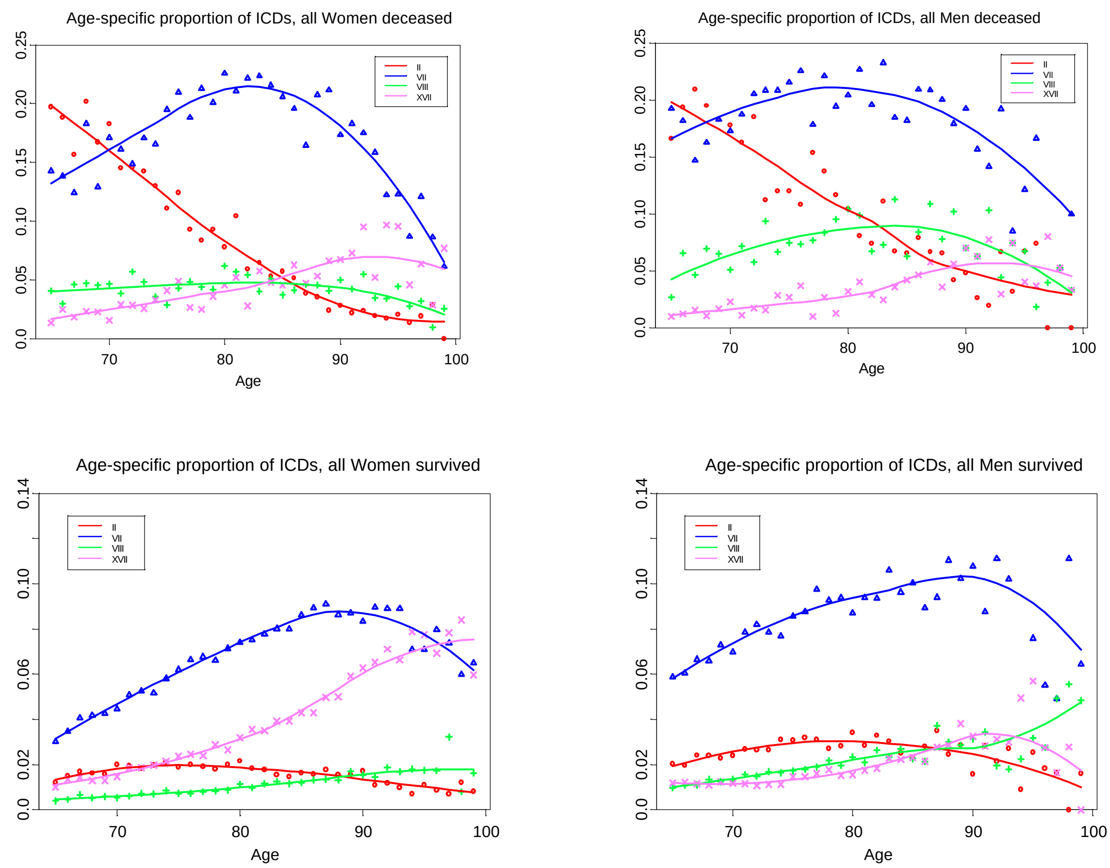
Our forecasts predict an increase in hospital expenditures for people 65 years and older in Germany until 2040 to 2050. After the German baby boomers - born between 1955 and 1969 - will die out, costs decline. Assuming an annual economic growth rate of 2%, a standard assumption for developed economies, GDP will be 2.44 times higher in 2045 than in 2000. In our projections hospital expenses will grow at a lower rate, so that they are covered by economic growth without any policy changes. Even if we allow prices for hospital care increase at a higher rate – it is often assumed that they may increase at a 1% higher rate than the entire economy grows, because services are labour intensive and productivity growth may be slower in the hospital sector - the growth of hospital expenditures seems to remain moderate.

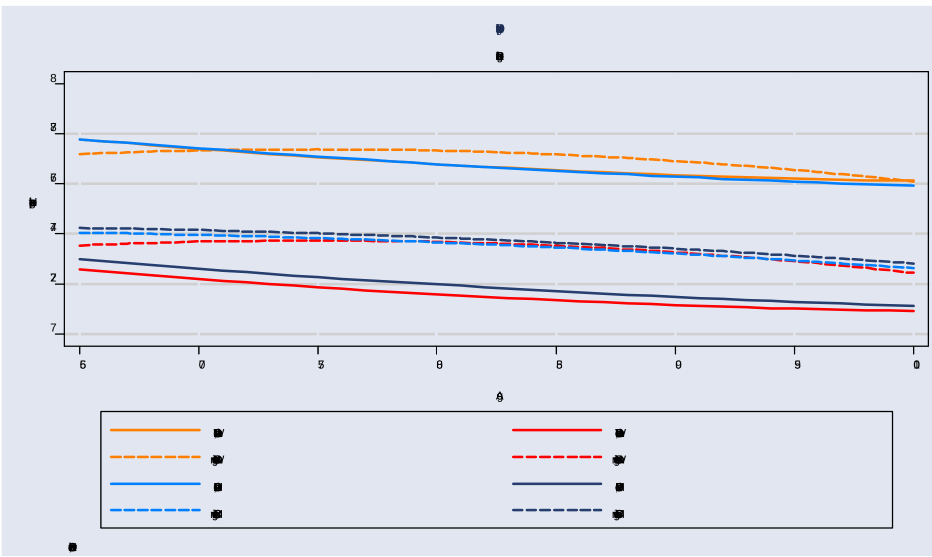
Two developments determine this outcome: longevity and medical progress. Longitudinal life-cycle studies have revealed that health care expenditures are not driven by age but by the proximity to death (i.e. Lubitz, Beebe, Baker 1995; Yang, Norton, Stearns 2003). Moreover, population aging implies that a growing number of older people will live longer and healthier. Consequently, future older people will need less medical care per capita (scenario 2).

Longitudinal studies also call into question that medical progress automatically induces higher health care expenses. On the contrary, if medical progress succeeds in curing (chronic) diseases, future health care expenditures should drop. We find an ambiguous impact of medical progress on hospital expenditures, when we apply empirical quality indicators of medical progress that mirror the patient's and public priority – more treatments and quicker recovery. Medical progress will increase hospital expenses only for men but not for women and its impact varies by disease. On the whole, the rise seems less dramatic than forecasts generally predict.

We can only speculate in this paper, why gender determines significantly future hospital expenses. Different mortality regimes, agism and sexism and technological path-dependence may translate into gender-biased expenditure patterns. The fact of the matter is however, that gender marks in all scenarios and on all levels a significant gap. In addition, we observe substantial variation between expenditure profiles of single diseases. Both gender and disease-specific variation signal room for improvement. These trends are sensitive to broader behavioral changes and health determinants and provide a strong basis for effective and efficient policy measures capable of promoting health and containing costs. Chronological age is instead a misleading indicator for predicting future health care expenditures. Our forecasts that apply the empirical findings of health care needs over the life-cycle and focus on quality outcomes of medical progress predict that population aging is affordable.

Figure 1: Proportions of ICD2, 7, 8 and 17 over age, separately for men and women and deceased and non-deceased patients.





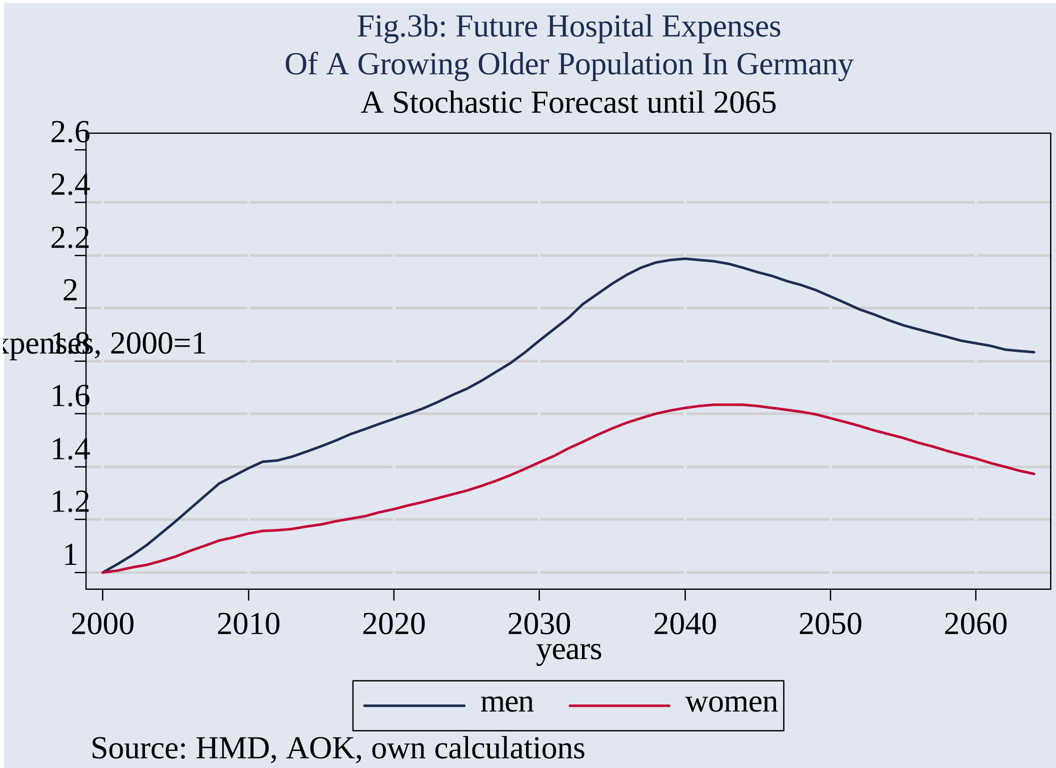
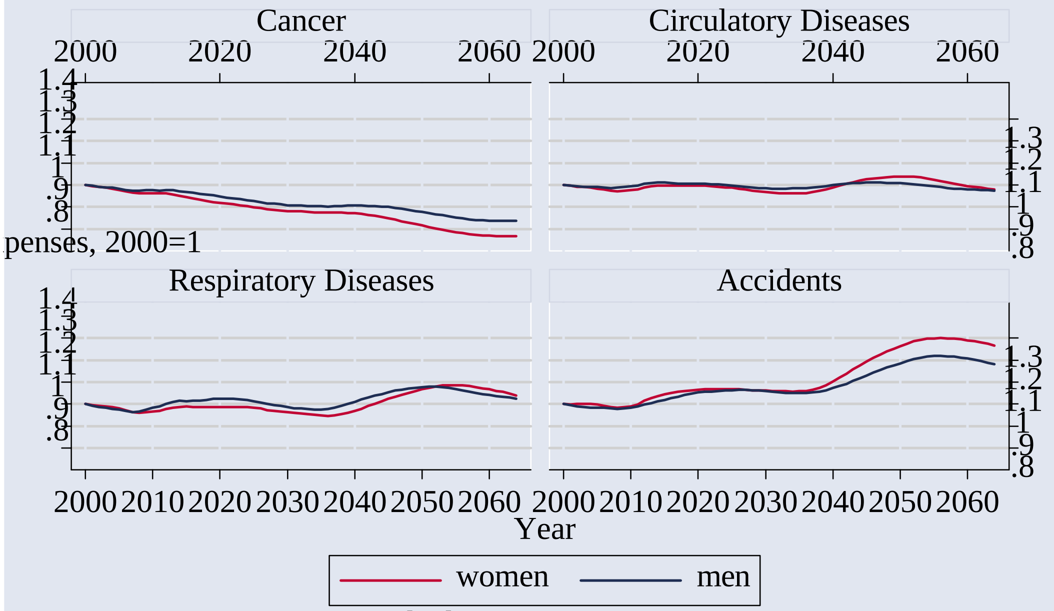


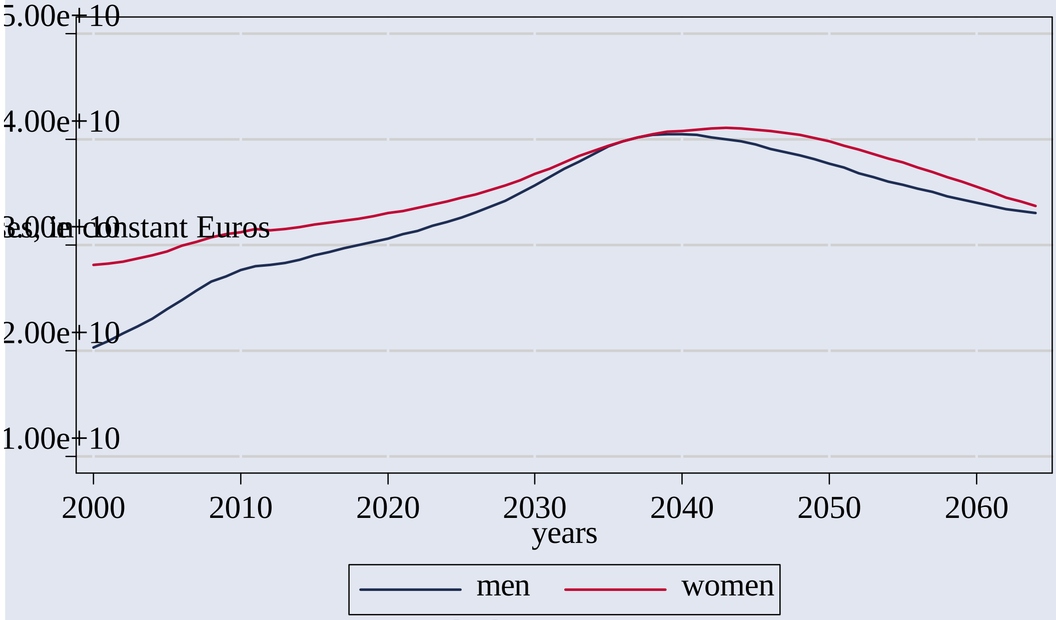
Fig.3b: Future Hospital Expenses
Of A Growing Older Population In Germany
A Stochastic Forecast until 2065
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
2000
2010
2020
2030
2040
2050
2060
years
men
women
Source: HMD, AOK, own calculations

Fig.4: Average Future Hospital Expenses
Of A Growing Older Population In Germany
A Stochastic Forecast until 2065



Source: HMD, AOK, own calculations

Fig.5a: Absolute Future Hospital Expenses
Of A Healthier Older Population In Germany
A Stochastic Forecast until 2065



Source: HMD, AOK, own calculations

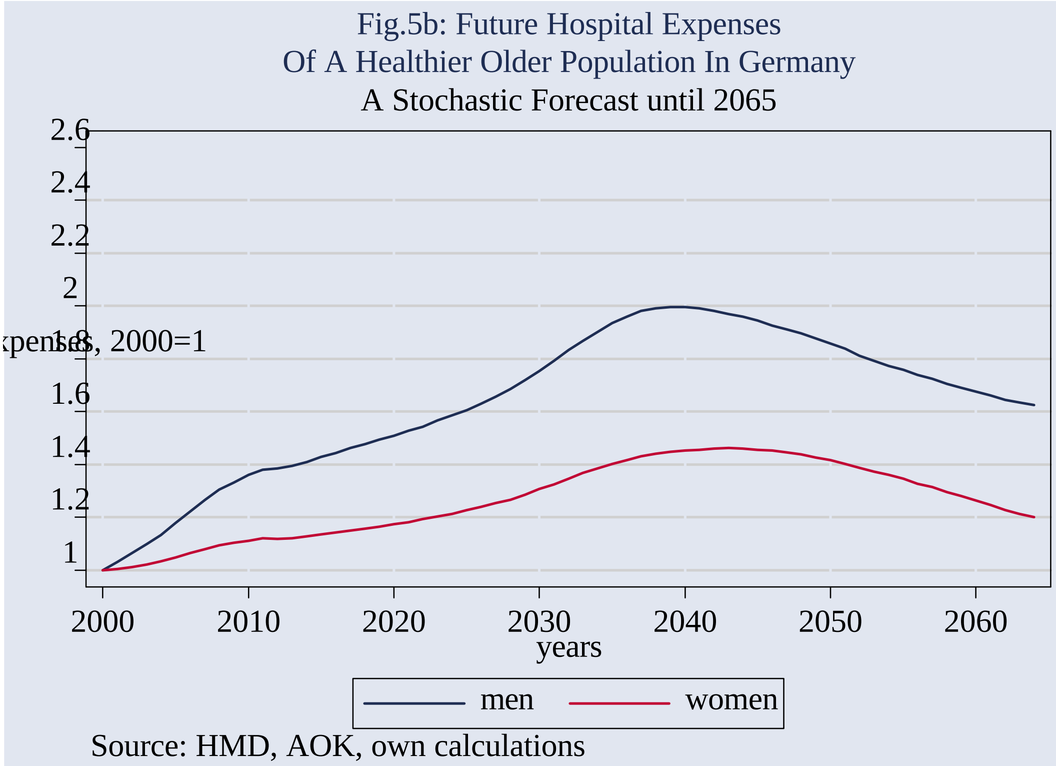


Fig.5b: Future Hospital Expenses
Of A Healthier Older Population In Germany
A Stochastic Forecast until 2065
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
xpenses, 2000=1
2000
2010
2020
2030
2040
2050
2060
years
men
women
Source: HMD, AOK, own calculations

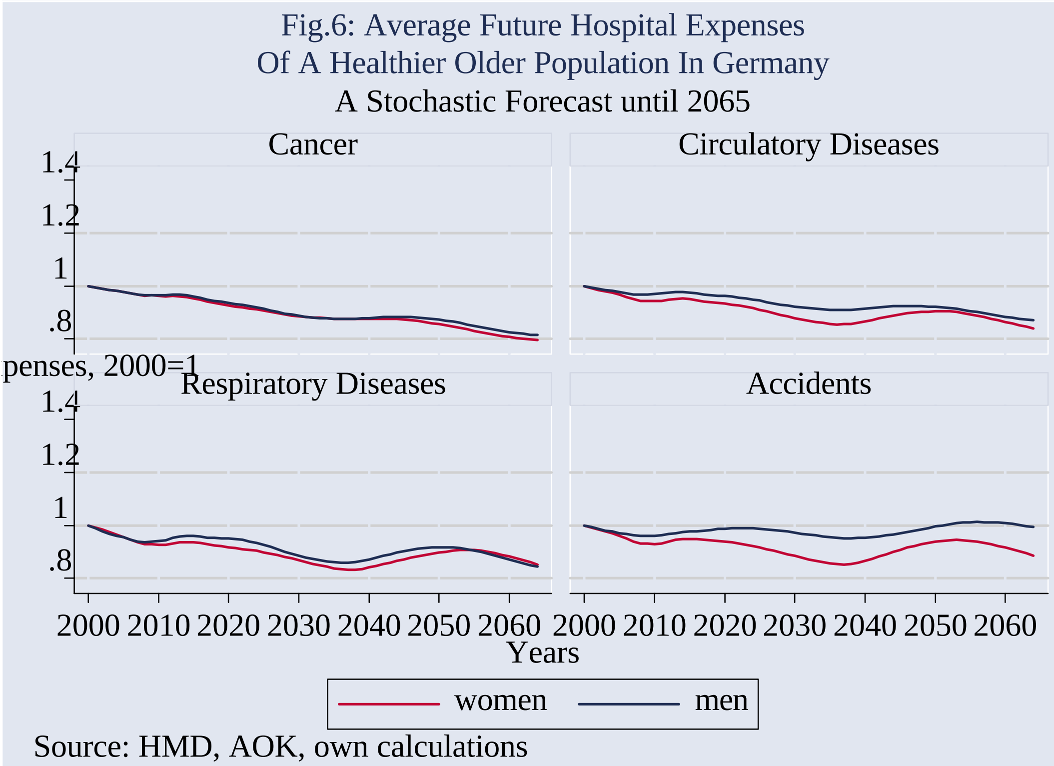
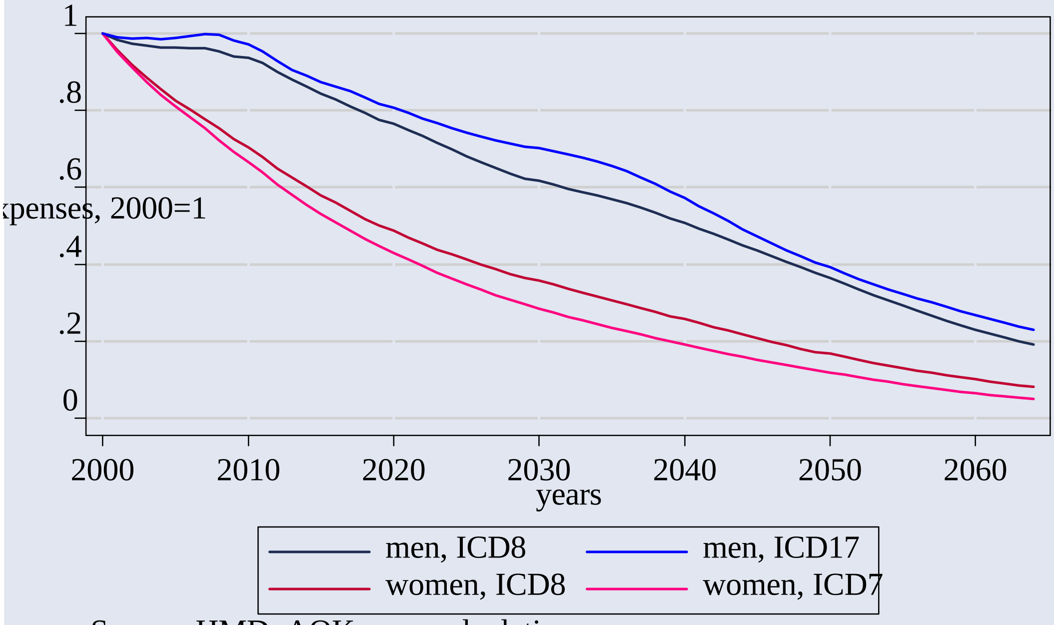


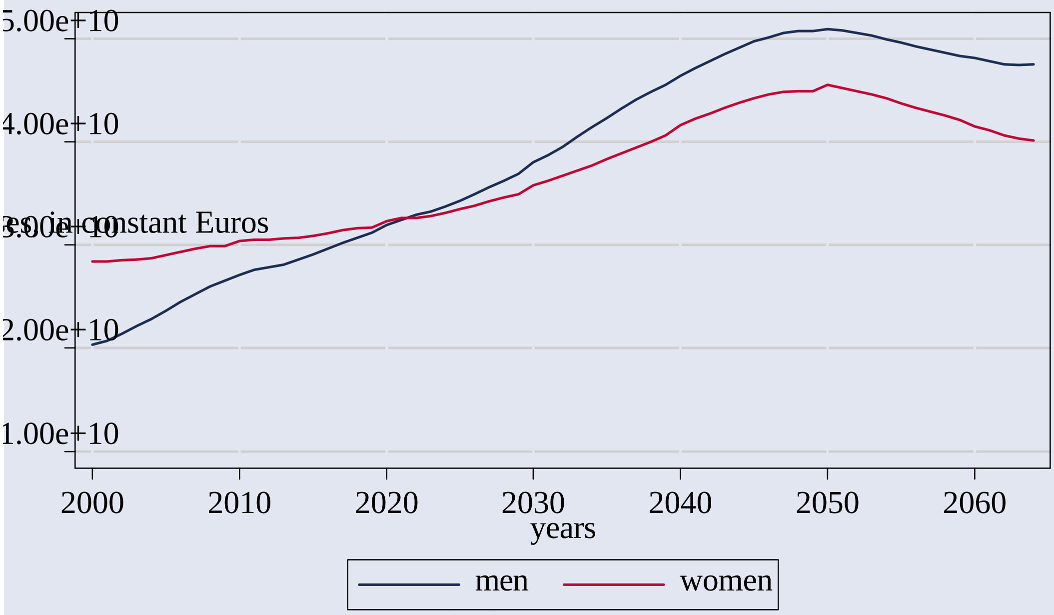
Fig.6: Average Future Hospital Expenses
Of A Healthier Older Population In Germany
A Stochastic Forecast until 2065
Cancer
Circulatory Diseases
Respiratory Diseases
Accidents
1.4
1.2
1
.8
penses, 2000=1
2000 2010 2020 2030 2040 2050 2060
Years
women
men
Source: HMD, AOK, own calculations

Fig.7: Future Hospital Expenses
By Reducing the Length of Stay
A Stochastic Forecast until 2065



Source: HMD, AOK, own calculations

Fig.8a: Absolute Future Hospital Expenses
Of A Healthier Older Population And Medical Progress
A Stochastic Forecast For Germany Until 2065



Source: HMD, AOK, own calculations

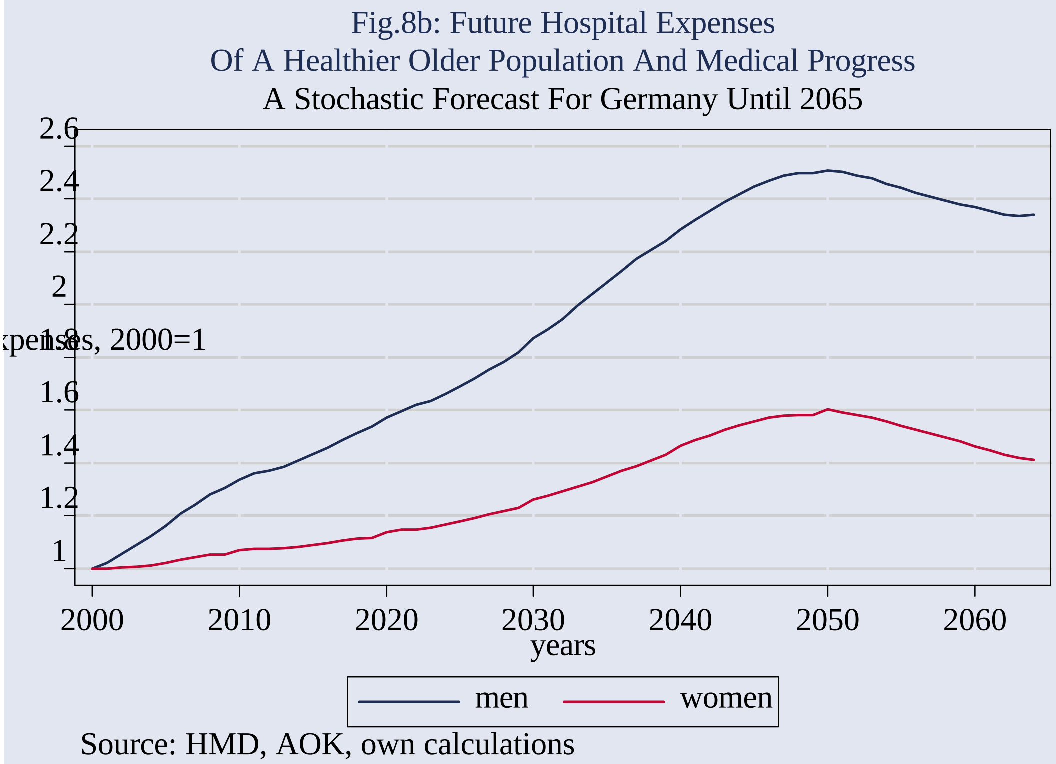


Fig.8b: Future Hospital Expenses
Of A Healthier Older Population And Medical Progress
A Stochastic Forecast For Germany Until 2065
expenses, 2000=1
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
2000
2010
2020
2030
2040
2050
2060
years
men
women
Source: HMD, AOK, own calculations

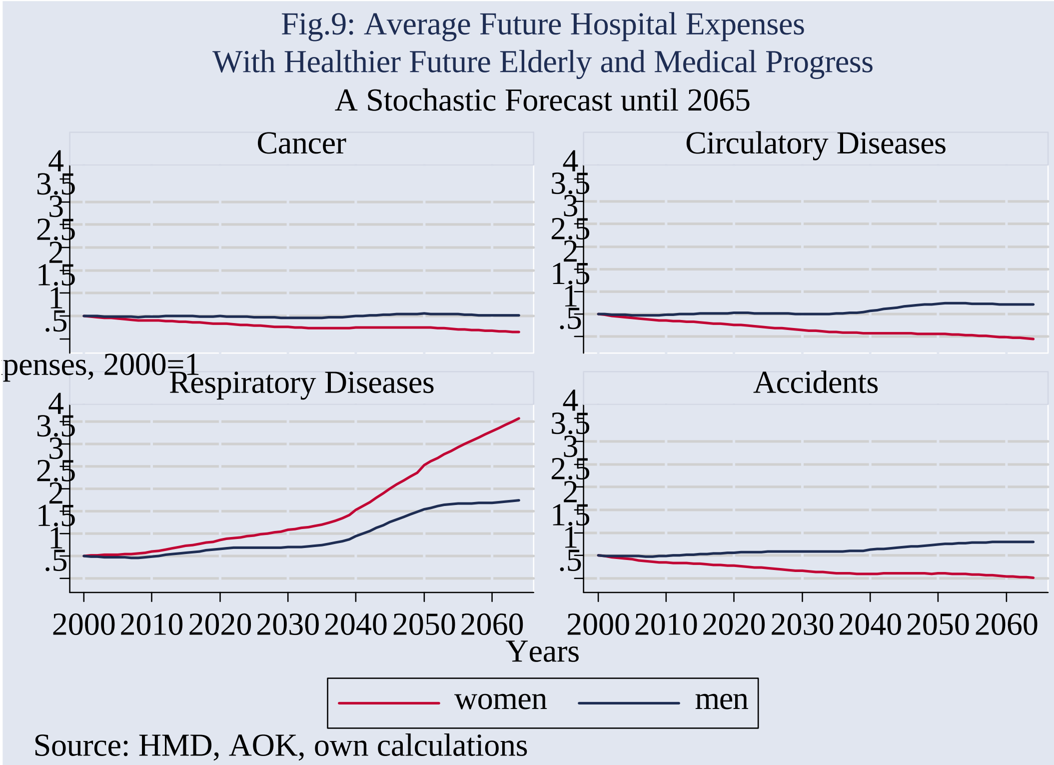


Fig.9: Average Future Hospital Expenses
With Healthier Future Elderly and Medical Progress
A Stochastic Forecast until 2065
Cancer
Circulatory Diseases
Respiratory Diseases
Accidents
expenses, 2000=1
4
3.5
3
2.5
2
1.5
1
.5
2000 2010 2020 2030 2040 2050 2060
Years
women
men
Source: HMD, AOK, own calculations

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