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"Steeping" Of Health Expenditure Profiles

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Content

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Abstract

If health care expenditure for the elderly grows faster than for younger people, the expenditure profiles become “steeper” – we call that "steeping”.

Three instruments for measuring “steeping” are presented: (1) trend of the relation between per-capita-expenditure of the old and the young; (2) comparing the linear slopes of per-capita-expenditure in age groups; (3) trend in parameters of non-linear modelling of expenditure profiles.

Using data of the largest German private health insurer over a period of 18 years, “steeping” could be observed by all three methods in most examined insurance plans.

A prognosis for 2040 shows that per-capita-expenditure will increase by 128 %.

keywords: health care expenditure, expenditure profiles, demographics

1. Introduction

Annual per capita health care expenditure can be described as a function of age. This function is different for men and women, and it also differs between the various sectors of the health care system like outpatient, inpatient and dental care. The graphs are called “expenditure profiles”. See Figure 1 for expenditure profiles of the total health expenditure of the largest private European health insurance, DKV[1], including inpatient, outpatient and dental care (in that figure, age group 0 is for insured below 1 year, age group 1 is for insured with age 1-4, age group 2 for insured with age 5-9, age group 3 for insured with age 10-14...). It has been well known for a long time, that annual per capita health expenditure in most sectors of health care

[1] DKV= Deutsche Krankenversicherung (engl: German Health Insurance)

rises with age and per capita health care expenditure is by far higher for older people than for young people. Hardly any studies have been done, however, to answer questions like: Does the shape of the graphs like in Figure 1 remain constant over time? Is the growth rate of annual per capita health expenditure the same within different age groups?

An answer to this question is crucial for understanding the future trend of health care expenditure, calculating a prognosis of future health care expenditure and creating answers to the challenge of increasing health care expenditure. This paper shall contribute to find an answer to the questions above.

Most models to forecast future per capita expenditure described in literature assume constant expenditure profiles. Sometimes it is argued that per capita health expenditure among older people increases by a higher growth rate than among young people; this means, that per capita health expenditure increases faster among older people than among young people. We use the term „steeping“ for this phenomenon, because it demonstrates steeper expenditure profiles over time.

Therefore we want to test the following hypothesis:

Expenditure profiles get steeper over time as the per capita expenditure for older people grows faster than that of younger people.

This hypothesis refers to total expenditure, outpatient care expenditure and inpatient care expenditure (but does not refer to dental care specifically) and it refers to the period of the 80s and the 90s of the last century.

In order to test this hypothesis, the paper describes in the next section the data used for the calculations, in section 3 the methods developed for measuring the phenomenon of steeping, and section 4 shows the results of employing these methods. In section 5 a prognosis for the increase of per-capita expenditure and the development of the average income-related contribution rate in the German public health insurance system is calculated, based on the assumption that steeping can be generalized to the public system and will continue over the prognosis period in the same form as it was observed within the observation period. In section 6 the results are discussed and the phenomenon of steeping is considered in the context of high per capita expenditure in the last year of life and increasing life expectancy, especially among older people. Some reflections on how to react on steeping are also given.

2. Data

The large majority of the German population, around 90 %, is insured in the public health insurance system. However, no longitudinal data for expenditure profiles in the public system are available. So the only chance to investigate the “steeping hypothesis” for Germany was to use data from the private health insurance sector. DKV provided the data of their main health plan system. In the analysis we included two outpatient plans with different deductible regulations (called OUTPATIENT1 and OUTPATIENT2) and their main inpatient plan (called INPATIENT); to make the picture more complete we also report descriptive data for three other outpatient plans (with other deductibles), but we do not include them in the measurement of steeping. We also included the supplementary plan, a health insurance plan which is created for publicly insured to cover inpatient services which are not covered by the benefit package of public health insurance (called SUPPLEMENTARY). In what follows the data for men in the plan INPATIENT is used to illustrate the results graphically. The benefit packages of these health plans include acute care, no long term care and only to a limited extent rehabilitation.

We did the same investigations on some aggregate data of the association of private health insurance companies (PKV-Verband), in which almost all of the German private health insurance companies are organised. The problem of these data is, that it is not transparent, which company delivered which data for which health plan in which year. So changes in the structure of the delivered data could have caused effects which may cover up the steeping effects. We will use these data from the PKV-Verband in the discussion section to compare our results of the calculations from the DKV data.

Although the DKV-data is probably the best available for studying the hypothesis of steeping for Germany, nevertheless the structure of the data still was the bottle-neck of our investigations. The data is not available for single insured, but only as annual sum of expenditure for an age group (aggregating for example the insured of age 30 years to 34 years) and the number of insured within each age group for each year of the observation period from 1979 until 1996. So average per capita health care expenditure could be calculated by dividing the total health care expenditure within an age group by the number of insured within this group in the same period of time. But the data could not help to investigate the correlation between steeping and the costs in the last year of life or to get some other more detailed information on the reasons of steeping.

Special problems arise within the health plan system of the DKV, because in 1986 a new outpatient plan without any co-payment (OUTPATIENT0) was introduced, whereas the plans existing before all had co-payments. This new plan was growing very fast and within five years it became the outpatient plan with most insured and within eight years there were more people insured in the new plan than in all other outpatient plans together. This had influence on the expenditure profile of the old plans: some insured – because of adverse selection probably more of the less healthy - changed from a plan with co-payment regulation to the new plan. Additionally most of the new insured choose the new plan, causing an ageing within the old plans. We do not report the results with regard to steeping for OUTPATIENT0 in this paper, because the time-period of observation is much shorter for the new plan than for the other plans. Additionally the cost development in a very new plan is different from elder plans, and this particular behaviour could distort the picture which we want to analyse.

3. Methods

3.1 Design of the study

In this retrospective study on aggregate data annual per capita health care expenditure was calculated for each age and gender group by dividing the total expenditure within the group by the number of insured in the same group. (As described below the per capita health care expenditure of the different age groups were combined to expenditure profiles.)

The dependent variable is the per capita health care expenditure; independent variables are the year of observation, gender and age group[2]. Because individual data is not available, the unit of the observation is a "(gender-specific) age group year": the smallest available unit of time is a year and the smallest unit of the sample

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[2] Age is calculated as year of observation – year of birth, so a change of age group within a year is excluded and the insured can not be in two different age groups within one year.

of insured is the age group.

3.2 Composing expenditure profiles

Starting point for the research of steeping are expenditure profiles. In general there are two ways of putting together age-specific per capita expenditure to compose expenditure profiles:

- For every year of the observation period the per capita expenditure of the different age groups are put together, forming a specific expenditure profile for every year. The per capita expenditure of different age groups within one profile is caused by different groups of insured. We call this the **year-approach**.
- For every cohort of insured the per capita expenditure is put together for an expenditure profile. A cohort is defined by the same year of birth or the date of birth of all insured within one cohort lies within the same period of time. A cohort expenditure profile is reflecting the per capita expenditure during the life cycle of this cohort. So a cohort expenditure profile is formed by per capita expenditure from different periods of time, but the per capita expenditures used for one cohort expenditure profile come all from the same group of insured. We call this the **cohort approach**.

Both approaches have their pros and their cons:

- Using the cohort approach it is - at least up to a certain degree - possible to distinguish between the effects of special birth cohorts and the effects of time trends.

- The cohort approach shows methodological problems: The general problem of this approach is, that expenditure profiles are put together using per capita expenditure from different periods of time. So it is necessary to filter the effect of inflation (and the not age-specific part of increase in health care expenditure).
- Because of the given structure of data, there is no way to isolate all the insured who were insured within a health plan over the whole period of observation. So the effect of switchers entering from other plans and other insurance companies or leaving to other plans and other insurance companies can not be seen. In our situation even in case of creating an expenditure profile by the cohort approach, the profiles could not be composed by using the life cycle expenditure of exactly the same group of insured.
- Because of the aggregation of the used data in fixed 5-years-age groups it is not even possible to calculate with the cohort approach expenditure profiles for every year. Only with a time distance of 5 years the per capita data for the group with the same birth period is given. So the profiles would have to be calculated by weighting the per capita expenditure of the overlapping birth period cohorts.
- Expenditure profiles of the year approach are easy to be calculated and there is no problem of data coming from different time periods within one expenditure profile[3].

Considering these issues it is evident, that using the year approach is the best choice for investigating the steeping hypothesis, at least with the data given. So the profiles used for Figure 1 are calculated by the year approach.[4]

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[3] The effect of inflation and increasing health care expenditure in the context of the comparison of different expenditure profiles is considered in the section on methods of measuring steeping.

3.3 Age constraints

The range of age of the insured used for this investigation was limited from 30 years to 79 years, what corresponds to the age groups 7 to 16. We had several reasons for introducing this constraint:

- Due to regulation of membership of mandatory public health insurance, there is a lot of entering into and leaving private health insurance companies below the age of 30.[5] Switching from a private insurance plan to public insurance or to another private insurance company is reduced significantly after the age of 30.[6]
- Number of insured in the sample cells of higher age groups, especially above 80 years becomes too small for analysis.
- In some cases the per capita expenditure of the very old do not increase any more compared to the younger age groups, sometimes the per capita expenditure do even decrease. We do not want to investigate this effect of the very old and it may cause problems or inaccuracy, especially in the use of the third of the methods described in this section.

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[4] German private health insurance companies themselves also use year approach profiles for the premium calculation (Bohn (1980)) as do most academics for prognosis of expenditures.

[5] Many young adults who were privately insured as kids become mandatorily insured in the public system when starting to work and have to cancel their private contracts. On the other hand, besides civil servants, the major groups of private insured in the German system are employees with income above the compulsory insurance threshold and self-employed people. A lot of employees reach this income threshold after finishing their university degree and starting their career or after some years of career, so their is a lot of entering into private insurance within the age group of 20 years to 30 years.

[6] In theory, insured can switch between private health insurers on an annual basis. However, private insurers in Germany calculate premiums on the capital funded method and insured loose the capital saved within one plan when switching, therefore after some years the price for switching is increasingly becoming too high (Meyer (1994)).

Figure 2 shows in a three dimensional diagram the idea of steeping. The expenditure profiles of the health plan INPATIENT for the age range of 30 years to 79 years using the year approach are set side to side for the years 1979 until 1996. It can be seen that the profiles become steeper over time. The effect of steeping is boosted in this diagram by inflation.

Three methods to measure steeping

To compare expenditure profiles especially referring to their age-specific per capita expenditure trend special instruments are needed. Because so far no such measuring instruments are published, we develop three different methods. They are described in the following paragraphs and their advantages and disadvantages are compared. The methods are

- *age-cut method*:

  time trend of the simple relation between per capita expenditure of "the old" to "the young" (cut-point at the age of 65 years)

- *age group specific expenditure increase:*

  comparison of the linear slope of per capita expenditure in the different age groups

- *exponential profile modelling:*

  time trend in parameters of non-linear exponential models of expenditure profiles over the years of the observation period

For the measuring of steeping only raw data is used. There is no smoothing or balancing used for composing the expenditure profiles. This makes sure, that no effects of any additional procedures can overlap real steeping effects or create artificial steeping effects.

3.4 Age-cut method (ACM)

A quite simple and transparent but at the same time a quite rough method to measure, how steep an expenditure profile is, separates the insured into two groups: the older and the younger. For the segregation a specific age is chosen as cut-point (in this case we used the age of 65 years). All insured younger than this age threshold are “the young” insured and all insured equal to or older than this threshold are “the old” insured. So this age threshold cuts the insured in two groups and this gives the method its name. For both groups their average per capita expenditure is calculated and the per capita expenditure of “the old” is divided by the per capita expenditure of “the young”. This "age-cut relation" shows how steep the profile is and if the relation is increasing over time, this is a sign for steeping. Summarising we use the following formula for the age-cut method:

$$AR_{65} = PCE_{65+} / PCE_{<65} \qquad (1)$$

with AR_{65} as the described age-ratio with age cut 65, PCE_{65+} is the per capita expenditure for all people older than or equal to the age cut, $PCE_{<65}$ the per capita expenditure for all people younger than the age cut.

A problem of this method is the high influence of demographic age trends within the two groups. In case average age is increasing in the older age group and average age keeps constant in the younger age group, keeping the entire rest constant the "age-cut relation" will increase showing a (misleading) sign of steeping although the profile did not change at all.

The age-cut method controls for the effect of inflation in the health sector automatically: If inflation is modelled by a factor, which has the same value for all insured, multiplying PCE_{65+} und $PCE_{<65}$ with that factor does not change the value of the age-cut relation.

An advantage of this method is its simple calculation and its high transparency. Up to a certain degree the results of this method can be compared with data from the public sector.[7] The two main disadvantages of this method are the high aggregation of data before the calculation of the index really starts and so the loss of a lot of information and the strong influence of demographic trends on the results of this method.

3.5 Age group specific expenditure increase (ASI)

For this method first the increase of per capita expenditure during the observed period in every age group is calculated, and then these age group specific increases are compared. A stronger increase in the higher age groups than in the lower age groups leads to a steeping of the profile. For measuring the increase of age group specific per capita expenditure we used a linear regression approach: For each age group we calculate a linear regression to model the development of the per capita expenditure. We use the following formula

$$\mathrm{PCE}_{\mathrm{Y}}^{\mathrm{AG}}/\mathrm{PCE}_{\mathrm{Y}}^{7} = \mathrm{a} + \mathrm{b} * (\mathrm{Y} - 1979) \qquad (2)$$

PCE_{Y}^{AG} is the per capita expenditure of year Y in age group AG, *a* and *b* are the values of the linear regression calculated by OLE. Slope *b* forms a measure of the average per capita expenditure increase of every age group during the observation period. For each profile investigated we get 10 age specific slope parameters *b*, because of the 10 age groups (7 to 16) for the age of 30 years up to 79 years.

For an unbiased comparison of the trends in per capita expenditure among different age groups, the per capita expenditure of each year has to be standardised. We do this by dividing all per capita expenditure of the single age groups by the value of the lowest age group of the used age range, which is age group 7 (30 - 34 years). So age group 7 gets in standardised profiles the value 1 and the slope *b* in this age group will therefore be 0 for all the investigated health plans. If we would not standardise the expenditure profiles but use the absolute per capita expenditure for each age group, inflation or a for all age groups equal growth rate would create a higher value of slope *b* within the higher age groups than within the lower age groups - without any real steeping effect. After standardisation parameter *b* is not anymore an average of increase in annual per capita expenditure of each age group. Instead it reflects the average annual growth rate of per capita expenditure relative to the growth rate in the lowest age group used (AG 7). Comparing these values b of different age groups within one health plan gives us information about the existence of steeping.

An alternative approach of this method could be to use the ratio of the per capita expenditure of the last year and the first year of the observation period within the age groups instead of slope *b* (e.g., Polder et al. (2002)). The advantage of this approach is, it is easy to calculate; the disadvantage is that a lot of information is not used and the influence of the first and the last year of our observation period are very strong. In case there is a special effect in one of these years, which contradicts the general

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[7] We will present data for comparison in the discussion section below.

trend over the observation period the result is biased. The approach of linear regression avoids this effect by giving all the years within the observation period the same weight.

This method shows also, whether the steeping is spread in the same way over the whole age range we investigated or not. For example it would detect if there is an age threshold up to which there is no steeping, but exceeding this age threshold the increase of per capita expenditure is definitely higher than in the age groups below the threshold.

The strength of the age group specific growth rate is the good graphical transparency and the independence of the age range. Because this method is a direct comparison of two or more expenditure profiles, there is no way to calculate a measure for a single profile.

3.6 Exponential profile modelling (EPM)

Besides the health plans for dental care an exponential function seems to be a good approximation for the expenditure profile of all health plans, especially for the age range of 30 to 79 years. We use a standardised exponential model including an additive variable, represented by the following formula

$$PCE_{AG} / PCE_{7} = c + \exp(d * AG) \qquad (3)$$

PCE_{AG} is the per capita expenditure of age group AG (age-group 7 to 16). The modelling function is characterised by two parameters c and d, which are calculated by non-linear modelling described in more detail below. The exponential parameter d forms a measure of how steep an expenditure profile is. For every health plan we investigated this method gives 17 values of the parameter d, because of the 17 years of observation from 1979 until 1996. The absolute value of the parameter d is not important in this context; important is the trend of this parameter over time. If the values of parameter d increase over some years the profile becomes steeper. Again standardisation was performed to elude any bias by inflation.

High values of R^2, which presents the proportion of the variance explained by the model, demonstrate the *good adoption* of the data by the exponential model. For most years and plans, the value of R^2 is over 90 % and there is no trend in the values of the R^2 over the observation period.

The question may arise, why we do not use the standard model of exponential modelling including a multiplicative variable, represented by the following formula

$$PCE_{AG} / PCE_7 = c * \exp(d * AG) \qquad (4)$$

With this specification not only parameter *d*, but also parameter *c* influences the slope of the curve, as can be seen by the derivation of the model function, assuming the age variable x is continuous. The multiplicative variable does not disappear in the deviation function and shows in this way its influence on the deviation and the slope of the curve

$$\tfrac{d}{dx}(c \cdot \exp(d \cdot x)) = c \cdot d \cdot \exp(d \cdot x) \qquad (5)$$

In contrast, the additive variable disappears in the deviation function of this specification with an additive variable:

$$\tfrac{d}{dx}(c + \exp(d \cdot x)) = d \cdot \exp(d \cdot x) \qquad (6)$$

A weakness of this instrument is the high degree of complexity. The model cannot be *linearised*, so methods of linear models and generalised linear models cannot be used for parameter calculation. For optimising the approximation of the model to the data we minimised - as it is standard - the squared errors. For solving the minimising problem the partial derivatives of the model function with respect to the two model parameters c and d are set equal to zero (the continuous variant of the model function is *differentiable*). These equations are called "normal" equations". Generally they can be solved only approximately, because it is not a system of linear equations. For the iterative process of approximation we choose Marquardt method, which is a compromise between Gauss-Newton method (Linearisation/Taylor-series) and steepest descent. The advantage of the chosen method - it converges relatively fast (Draper, Smitz (1998); SAS Institute (1990)).

Besides estimating the model parameters several statistical measures are calculated. Instead of the normally used variances and confidence intervals asymptotic standard error and asymptotic confidence intervals are calculated for the non-linear regression parameters. These are values of the linear regression model, created by *linearising* the model function around the estimated model parameters. This approach assumes that the linearised model gives a good approximation of the non-linear model.[8]

The strength of using the model (3) is that one parameter can characterise, how steep the expenditure file is and the whole information is used for the parameter calculation. The bias of inflation is excluded and this method delivers good conditions of graphical presentations. Disadvantages of this method are the complex calculations, which makes it impossible to use this method without a powerful statistical software, the lack of immediate transparency, and the fact, that there is no clear and concrete meaning of the parameter d external to our measuring the steeping of expenditure profiles.

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[8] (Draper, Smitz (1998); Dufner et al. (1992); Schübo et al. (1991); SAS Institute (1990))

Strength of all three methods presented in this section is, that there are no other data used from outside the data set, like cost or price indices, to standardise the data. The use of such extern indices may cause bias compared to the calculation within the "closed systems" of the used data.

4. Results

We start the description of the results with some notes on the sample size and its trend during the observation period of the health plans used for the investigation. Generally the number of insured was growing over the time. Number of insured are lower in health plans with higher co-payments (OUTPATIENT3 and OUTPATIENT4) than in health plans with lower co-payment (OUTPATIENT1 and OUTPATIENT2) or no co-payment (OUTPATIENT0), and the growth in number of insured was mainly in the health plan without co-payment. The trend in the outpatient health plan system is documented for men in Figure 3.

By far the most insured are insured in the health plan SUPPLEMENTARY. Age structure of insured is quite different among the investigated health plans: for the age groups of 80 years and older and sometimes also for younger age groups the sample size is a lot lower than in middle age groups. Table 1 gives an overview over the number of insured within the single health plans we include in the analysis for the year 1996, which is the last year of our observation period.

In most examined insurance plans steeping was found in the period of observation by all three methods. Methodological constraints make the direct comparison of different health plans and between sexes impossible. But the health plans of men seem to show stronger "steeping" than those of women and inpatient plans seem to show stronger "steeping" than outpatient plans.

Before starting with the results we make three remarks on the data used, the influence of co-payment adaptation and the illustration of the results:

- The data of the DKV include two different types of claim data: (i) the sum of claims the insured sent to the insurer, and (ii) the sum of payments made by the insurer to the insured.[9] Generally the first value has to be equal to or higher than the last value, because the insurer will not pay more money to the insured than they ask for, but in some cases the insurer may not accept the claims insured have sent or pays only a part of the claim because of the co-payment regulation. In this paper we present results for the second type of data. Only for the outpatient health plans we investigated both types of data to get some information on the influence of the amount of co-payment on the form of expenditure profile and on the trends in expenditure profile development.
- The higher the deductible the larger is the difference between the values of the two different claim data and the larger is the share of that difference in relation to the sum of claims sent to the insurer. That share actually was decreasing in all plans during the period of observation, sometimes interrupted in the years of a discretionary increase of the deductible (in order to match inflation). A decreasing relevance of the deductible ceteris paribus causes a flatter profile and in this way covers steeping effects. So within the outpatient health plans the true steeping effects may be underestimated.
- The results are illustrated graphically for men in health plan INPATIENT. We

[9] In case a deductible is larger than medical costs, a insured does not sent any claims in. The sum of claims sent in is therefore not identical with medical costs of the insured.

do use this health plan, because the sample size of this health plan is relatively high, it does not include any co-payment regulation, which could influence the steeping effect. Also this health plan existed over the whole period of observation and it was not possible to switch to any other inpatient health plan within the DKV-system.

4.1 Age-cut method

As described above, in the age-cut method steeping is expressed as an increase of the age-ratio during the observation period. Except for men in health plan OUTPATIENT1 in all other health plans for men investigated age-ratios do increase over the period of observation, including some up and down movement; for women steeping can be observed in all plans (see Table 2). There is less up and down movement in the course of the age-ratio of inpatient health plans than of the outpatient plans, the smoothest increase of age-ratio is observed for health plan SUPPLEMENTARY. This may be due to the higher number of insured in the inpatient health plans.

A graphical illustration is given in Figure 4 for the men in health plan INPATIENT: the age-ratio in that plan increases from a value of 4.3 (1979) to a value of 6.5 (1996). This means that the average per capita expenditure of insured older than 64 years in 1979 is "only" 4.3 times the average per capita expenditure of insured younger than 65 years, whereas until 1996 this relation increases up to a value of 6.5. Average age within the younger group kept within a range of 39 and 41 years, average age within the older group kept within a range of 72 and 73 years. So we can assume, that in this case the impact of changes in the age structure on steeping are very small, and they do not influence the phenomenon of steeping as measured by the age-cut method.

A special situation we do find for health plan OUTPATIENT1: the course of the age-ratio of men in this plan is very different from the course in all the other plans and for women in the same plan. Until 1985 a steep rise of the age-ratio can be observed from a value of 3.5 to a value of 4.5, from 1986 the value is decreasing to a value of 3.7. At least a partial explanation for this unexpected course of the parameter may be the fact that the average age within the younger age group increases by 7 years from 36 to 42, whereas the average age within the older age group keeps more or less constant at the value of 73. More important seems to be the fact that the new outpatient plan OUTPATIENT0 without any co-payment regulation was introduced in 1986 and many insured switched especially from OUTPATIENT1 to OUTPATIENT0, because health plan OUTPATIENT1 was the plan with the lowest co-payment regulation so far.

To get an idea, how sensitive this method reacts on different age-cut points we perform this method as well using the age-cut point 60 years. The results show only slight differences to the results using cut point 65 years. The movements around the general trends are smaller, which is because the “old age group” becomes bigger balancing outlier effects better in this group.

4.2 Age group specific expenditure increase (ASI)

This method uses the linear slope as average annual per capita growth within the different age groups and steeping is shown by an increase of the "standardised" slope (parameter *b*) comparing younger age groups with older age groups. We observe steeping for most plans and both sexes.

In health plan INPATIENT for men parameter *b* is increasing from age group to age group almost monotonously (see Figure 5). Only in the age groups 8 and 10 (35-39 and 45-49 years) small deviations from this rule are observable. For the higher age groups the increase of *b* becomes bigger. For men in plan INPATIENT the form of the bar diagram of parameter *b* shows the form of an exponential function.

Generally the changes in the expenditure profiles are stronger for men than for women: increase in per capita expenditure is for men in most investigated plans smaller in lower age groups and stronger in higher age groups than for women. Because of the standardisation of expenditure profiles within this method this fact can only be seen by a higher parameter *b* in the highest age group. In most of the plans parameter *b* is increasing by increasing age, so steeping is observed in these plans - at least for some age groups: For the outpatient plans within the lower age groups a decreasing parameter *b* is observed falling into negative values[10]. Between age groups 10 and 12 parameter *b* begins to increase in the two outpatient plans up to age group 16. Dividing the period of observation in two parts – one before the introduction of the co-payment free plan and after its introduction – we get the following pattern: Until mid 80s (including 1985) we get a clear - and for plan OUTPATIENT1 very smooth - increase of parameter *b*. From 1986 until 1996 no clear pattern can be recognised, but most of the values of parameter *b* are negative and there is definitely no sign of steeping. An almost monotonous increase and an exponential form of the bar diagram is seen in the inpatient plans. The bar diagram for health plan SUPPLEMENTARY is even smoother than for health plan INPATIENT.

Comparing all health plans it seems to be a rule, that the highest linear slope is observed in the highest age group. An investigation of the range of values shows that slope values are higher for men than for women and for both sexes they are higher for inpatient plans than for outpatient plans, and they are larger with larger deductibles.

Looking at the significance of parameter *b* the results described so far can be confirmed: For age group 7 we do not expect any value different from 0, because the method was created in a way that the value of age group 7 is equal to 1 in any standardised expenditure profile and the slope parameter *b* of linear regression has to be 0 in this method by definition. So for the age groups close to age group 7 no values significantly different form 0 are expected, because the differences to age group 7 are quite small. For the inpatient plans there is again a quite uniform pattern: in higher age groups (in most of the cases form age group 10 on) the slope is significantly different from 0. Less clear is the situation for the outpatient plans: only for some plans we can find the above described pattern. The reason for this difference is, that we observe in some plans a decreasing per capita expenditure slope compared to age group 7 within the younger age groups of the observed age range (resulting in negative values of in these age groups). The steeping in higher age groups is reflected by values of parameter *b*, which increase from negative values to positive values. So there is steeping within the higher age groups but no parameters b, which are significantly different from 0. Restricting the observation period to the time before the introduction of plan OUTPATIENT0, we get the expected pattern of parameters *b* significantly different form 0 in higher age groups

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[10] This does not reflect decreasing per capita expenditure in these age groups, but growth rates, which are smaller than the growth rate of age group 7.

as in inpatient plans.

Summarising we can see steeping – measured by ASI – in all plans investigated. In outpatient plans it is observed only for the higher age groups or only before the introduction of plan OUTPATIENT0.

4.3 Exponential profile modelling (EPM)

This method approximates the expenditure profile by an exponential function and steeping is shown by an increase of the exponential parameter *d* over the observation period. R squares of the exponential model exceed 90 % in most of the cases, so we can assume that the used model presents a good tool for approximation.

Figure 6 shows the modelling of the standardised expenditure profiles for the data of men in plan INPATIENT for the years 1979 and 1996 by comparing original data and its approximation by the exponential function (3).

Values of parameter *d* are lower for women than for men, indicating steeper profiles for men.

Using the EPM methodology, over the total period steeping can be observed in all health plans and for both genders (see Table 3). For the investigated plans the asymptotic confidence interval does not include 0 in any case.

For a graphical illustration for men in the INPATIENT plan see Figure 7. The figure shows that there is some up and down movement, but nevertheless d is clearly increasing over the whole period of observation from 1979 to 1996. For the plans OUTPATIENT1 and OUTPATIENT2 until the years 1983 respectively 1984 for both sexes a steep rise of parameter *d* is observable indicating a strong steeping of the profiles in this time. Afterwards parameter *d* is decreasing somewhat, ending in some up and down movement of the parameter. For the inpatient plans we can observe steeping over the whole period of observation (see Figure 7). Especially in plan SUPPLEMENTARY the increase is very smooth.

To get an idea, how sensitive this method reacts on different age restrictions we perform the method as well using the age range from 50 to 70 years. We get for investigated plans lower values of parameter *d* than in the original analysis, for women this is true only for the outpatient plans. Only few qualitative differences in the trend of the development are found: The course of parameter *d* which turns for the outpatient plans OUTPATIENT1 and OUTPATIENT2 in the original analysis mid of the 80s, does not change in this analysis of more restricted data, but a consistent increase of parameter *d* over the whole period of observation is seen. Besides this effect there is almost no sensitivity towards the age range to be observed.

Summarising we observe a steeping (measured by EPM) in the inpatient plans and until the mid 80s in outpatient plans. For the time afterwards no clear statement for outpatient plans is possible based on the used data.

5. Prognosis

To estimate the impact of steeping and its interaction with an ageing population on the German health care system for the next decades we calculated a prognosis of the future increase of per-capita expenditures and of the average contribution rate of sickness funds[11]. For this prognosis we assumed, that the effect we found by using

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[11] In the public health insurance system in Germany income-related contributions have to be paid (including a threshold of a maximum contribution), and each sickness fund has to calculate a

data of private health insurance will continue and can be generalised to the public health insurance system, which covers some 90 % of German population; we will show in the discussion section that there are some indicators for steeping in the public system as well, therefore we believe that the generalisation is valid. The prognosis of the number and the age structure of the population is based on the latest prognosis for the whole population of Germany performed by the Federal Statistical Office Germany, which assumes constant birth rates of 1.3 birth per women[12] until 2040 and an annual net immigration to Germany of 100 000 people. Endpoint of the prognosis is 2040, so we calculated a prognosis for the increase of per-capita expenditure until 2040 and for the average contribution rate of the year 2040. For estimating a short to middle term value, we also calculated a prognosis for 2010.

Because the comprehensive benefit package of public health insurance covers services of outpatient, inpatient, and dental care, we constructed a health plan "COMBI" by adding per capita expenditure of health plans OUTPATIENT1, INPATIENT and a health plan for dental care. To get a more realistic estimation of the future per capita expenditure and the average contribution rate it was necessary to include the age groups below 30 years and above 79 years in these calculations, which were excluded from the calculations in the preceding sections. We assumed, that age specific increase is equal to zero for the age groups below 30 years (in 9 of twelve of these age-gender groups the confidence interval of slope parameter b in the ASI method included the value of zero) and used for the profile the average value

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contribution rate as share of their members income which covers its expenditure. Across all sickness funds an average contribution rate can be calculated.

[12] For East Germany it is assumed that the birth rate will rise from 0.8 to 1.3 until 2005.

of the standardised profiles from 1979 until 1996. For the age groups above 79 years we assumed the same values and trends as in the highest age group of the investigated age range (75-79 years). This seems to be a careful assumption, because almost all per capita expenditure for age-gender groups over 80 years were in the period of 1979 until 1996 higher than within the age group 75 - 79 years.

For the prognosis we used the ASI-method. So we calculated the linear trends of total per capita expenditure, extrapolated these trends until 2010 respectively 2040 to get standardised expenditure profiles of these years.

Figure 8 compares the standardised expenditure profile 1996 with the forecasted standardised expenditure profiles for 2010 and 2040 using the following formula (for 2010):

$$\mathrm{PCE}_{\mathrm{AG}}^{2010}/\mathrm{PCE}_{7}^{2010} = \mathrm{a}_{\mathrm{AG}} + \mathrm{b}_{\mathrm{AG}}\left(2010 - 1979\right) \qquad (7)$$

PCE $_{AG}^{2010}$ is the per capita expenditure of age group AG in year 2010 (formula for 2040 analogous) and a_{AG} and b_{AG} are for each age group the parameters of linear regression of age group specific per capita expenditure of the standardised expenditure profiles within the period from 1979 until 1996.

Using the population projection and the standardised expenditure profile of 2040 we can calculate the increase in total expenditure of the system and the increase in per capita expenditure. The increase of the average contribution rate is calculated with the help of the construction of per capita expenditure of "contribution payers". This controls especially for the trend of a decreasing number and share of children among the insured. This relieves the contribution payers, because children are insured for free in the public health insurance system, if parents are insured in the public system; we do not consider variables on the income side of the insured (like the ratio between wages and pensions), which may also have an impact on the average contribution rate (Knappe (1995)).

Table 4 shows the result of the prognosis: Per-capita expenditure increases by about 128 % until 2040, and the average contribution rate almost doubles from 13,4 % in the base year to a value of some 26 %. The steeping of the expenditure profile has quite a high influence on this increase; the pure demographic effect is considerably smaller. Per-capita expenditure will increase by about 31 % and contribution rate will increase according to our calculation until 2010 to a rate of some 16 %. So most of the effect will be realised after the next decade.

For getting an impression of the sensitivity of the prognosis towards the assumptions we made, we calculated several alternative approaches:

- using elements of public health insurance,
- correcting for not taking into account the special effect of sickness allowances, which are covered partly by the benefit package of the public sickness funds, but not included in the "health plan" COMBI, and
- using a population prognosis model including higher net immigration (200 000 people per year).

The results of these sensitivity analysis shows some sensitivity of the prognosis towards changes in the assumptions, but the effects are quite small and do not change the general statement of an substantial increase in per capita expenditure and the average contribution rate of sickness funds as a consequence of steeping and an ageing population. A higher number of immigrants does not seem to be aa solution to the problem, at least not an immigration of the scale we investigated.

6. Discussion

This paper has demonstrated that a considerable amount of “steeping” can be observed at least for the period of the 80s and the 90s of the last century within the data from the large private health insurance we used. Using these results for prognosis, a sharp increase of per capita expenditure was forecasted, especially in combination with a prognosis of the future age structure of the German population. Doing such a prognosis assumes, however, that the data we used can be generalised. Therefore in this section we first discuss how valid a generalisation of these results is. We compare the results presented with more aggregate data of all German private health insurers collected by their association PKV; we also want to use some very crude data of the public system. And we briefly report some results from studies using data from other countries. Finally we discuss possible reasons for steeping and possible reactions of health care systems.

6.1 Is steeping a general phenomenon?

As mentioned above, there is some more aggregate data available from the private health insurance association. This data has its deficits, as changes in the structure of the data delivered by the various companies from year to year could have distorted the results. Due to restrictions in the structure of the data, it was not possible to test the Age cut method, however we could calculate parameters for Age group specific expenditure increase and for Exponential profile modelling. For both methods, the results are quite similar for this data in comparison with the DKV data, especially in the 1980s. However, in the 1990s in the data of the private health insurance association steeping cannot be established, but in the 1970s steeping can be established in this data, especially in the inpatient plans. Altogether we can argue that steeping existed not only in the DKV data, but also in the aggregate data collected for the whole private health insurance sector in Germany.

It is also very useful to compare our results with data from the public health insurance system – as far as it is possible. As mentioned above, age expenditure profiles for a longer time period can not be constructed for social health insurance. However, for legal reasons, routine data of social health insurance can be differentiated into the two “age groups” of “pensioners” and “non pensioners” – although these do not coincide with any real “age groups”[13]. For these two “age groups” the “age cut method” can be applied with $AR_{P/NP} = PCE_P / PCE_{NP}$ where PCE_P and PCE_{NP} are the per capita expenditure for pensioners respectively non-pensioners and $AR_{P/NP}$ is the age-ratio between these two groups.

Figure 9 shows the development of $AR_{P/PN}$ for the period from 1950 to 1996. It can be clearly seen that there was steeping during the whole period and also during the period from 1979 to 1996, for which we have our DKV data. Whereas $AR_{P/NP}$ was 0,47 in 1950, it was 1,08 in 1979 and 1,76 in 1996. As these values are “per member” and the elderly have considerable less insured children than the younger, the quite low values of $AR_{P/NP}$ can not be a surprise. What is interesting for us, however, is the trend of this value, which confirms steeping.

Therefore it seems to be plausible to generalise our conclusions regarding the steeping hypotheses from the DKV data to more general populations in Germany.

There are hardly any reliable data published concerning the development of expenditure profiles for other health care systems. OECD (2001) reports per capita

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[13] Some pensioners are below age 60 and some „non pensioners“ are beyond age 65; also the values for per capita expenditures are available only for „members including dependent“, not per insured.

expenditure for total health care costs for the elderly (65+) in comparison to the young (65-) for several countries. A longer time series was only available for Canada and for Japan. In both cases steeping could not be observed. A recent study published for the Netherlands (Polder et al. (1994)) demonstrated steeping for acute care (like in this paper), which was compensated with slower growth rates for the elderly in long term care (which was not covered in our study).

6.2 Reasons for Steeping?

With our data we can not analyze reasons for steeping. In this section we want to discuss, however, potential effects which may have caused steeping:

- A change in the *patterns of morbidity* can cause a larger increase of health care expenditure for the elderly, especially an increasing chronicity of diseases with a larger prevalence among the elderly. It is also argued that multi-morbidity is increasingly becoming a common fact among the elderly and this might lead to an increase in the number and intensity of interventions in comparison to the young.
- There is evidence that people living in *single-person households* use more health care services and cause higher expenditure than persons living in families (Enquete-Kommission des Deutschen Bundestages (2002)). The share of elderly living in single-person households as proportion of all households has increased and will cause steeping c.p.
- *Technological changes* might work different for the young and the elderly: Polder (2002) conclude for Dutch data that at younger ages technological change causes a relative reduction in acute care costs, while for older groups is causes an increasing number of interventions and raise per capita expenditure.

- Neither increasing life expectancy nor the fact that the last year of life is extremely expensive for health care systems (Lubitz et al. (1993); van Vliet, Lamers (1998)) nor the combination of these two trends can help to explain the phenomenon of steeping: Assuming per capita expenditure is a function of age only, an increasing life expectancy causes a change in the number of people within the different age groups, but no change in the expenditure profiles could be observed. Assuming extreme expenditure in the last year of life has influence on the per capita expenditure and expenditure profiles, there is no change in expenditure profiles expected as long as mortality structure keeps the same in the observed population. Assuming a considerable influence of the expenditure in the last year of life on age-specific per capita expenditure and at the same time assuming an increasing life expectancy, an effect on the expenditure profiles is to be expected. How this effect looks like, and whether it could explain the phenomenon of steeping depends on the details of the change in morbidity structure. In case there is a more or less equal reduction of morbidity in all age groups, the expenditure profile would become more flat: Because of the higher morbidity among the elderly the influence of the higher per capita expenditure in the last year of life show greater effect on their age specific per capita expenditure than in younger age groups. So a reduction in morbidity by the same factor for all age groups leads to a stronger reduction of the age specific per capita expenditure in older age groups than in younger age groups and the expenditure profile becomes more flat (in case the morbidity reduction would concentrate in the higher age groups the profiles would become even more flat and a morbidity reduction concentrating among the younger groups would lead to a steeper profile). In fact in the last decades morbidity reduction seemed to be quite equal in the age groups beyond 30 years, so steeping can not be explained by this trend.[14]

It is likely that a combination of all of these trends – not including the last issue - has led to steeping.

6.3 Consequences of steeping

In terms of intergenerational fairness in health care systems financed by the pay-as-you-go mechanism, steeping provides a paradox: On the one hand it means that each generation will be "winning", because it c.p. gets more out of the system than it has paid into the system. At the same time, in an ageing population steeping leads to rising per capita expenditure and increases the burden for publicly financed health care systems. Especially the younger generation has to face this increasing burden in such a situation. It is unlikely that on the long run the younger are willing to finance the consequences of steeping; not knowing whether the next young generation will bare the burden, when they reach old age and need the financial support of this next young generation. Steeping therefore undermines the trust into the functioning and reliability of such a publicly financed health care systems and the contract of generations, which stands behind the pay-as-you-go system.

In the European Union there is increasing awareness that the challenge of ageing for health care systems will be to find a new balance between access, quality and cost-containment. Mechanisms to raise technical efficiency and to limit benefit packages

[14] Age group specific relations between the average expenditure of survivors and the average expenditure of dying persons and the trend of change in this relation can also influence change of expenditure profiles. Finally this effect, as far as it could be considered, did not deliver an explanation of steeping.

to cost-effective services will have to be implemented. The discussion, whether health care costs of the elderly will be a special focus of such policies, has just started.

7. Acknowledgements

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Bibliography:

Bohn K (1980) *Die Mathematik der deutschen privaten Krankenversicherung*. Verlag Versicherungswirtschaft: Karlsruhe

Draper N, Smitz H (1998) *Applied Regression Analysis*. John Wiley & Sons: New York

Dufner J, Jensen U, Schumacher E (1992) *Statistik mit SAS*. Teubner: Stuttgart

Enquete-Kommission des Deutschen Bundestages "Demographischer Wandel-Herausforderung unserer älter werdenden Gesellschaft an den Einzelnen und die Politik" (2002) Zur Sache. Berlin.

Knappe E (1995) *Auswirkungen des demographischen Wandels auf den Gesundheitssektor* in: Oberender P (Ed.), *Transplantationsmedizin, ökonomische, ethische, medizinische und rechtliche Aspekte*. Nomos: Baden-Baden, pp. 11--41

Lubitz JD, Riley GF (1993) *Trends in Medicare Payments in the Last Year of Life.* The New England Journal of Medicine **328**: 1092--1096.

Meyer U (1994) *Gesetzliche Regelungen zu den Berechnungsgrundlagen der privaten Krankenversicherung*, in: Schwintowski HP (Ed.), *Deregulierung, Private Krankenversicherung, Kfz-Haftpflichtversicherung. Beiträge der Dritten Wissenschaftstagung des Bundes der Versicherten*. Nomos: Baden-Baden, pp. 86--111

OECD (2001) *Health Data File*. OECD. (CD-ROM)

Polder JBL, Meerding W, van der Maas P (2002) *Age-specific increases in health care costs.* European Journal of Public Health **12:** 57--62

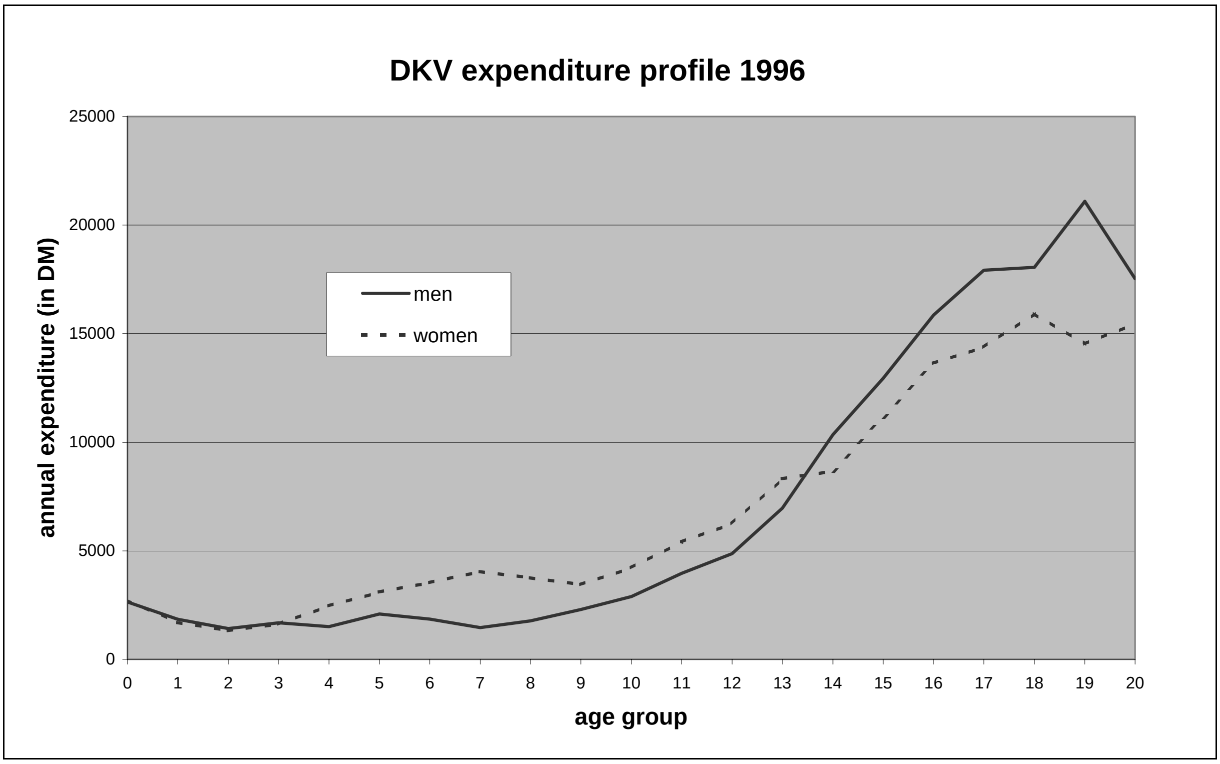
SAS Institute (1990) *SAS/STAT User's Guide. Version 6 Fourth Edition, Vol. 2* SAS Institute, Cary

Schubö W, et al. (1991) *SPSS: Handbuch der Programmversion 4.0 und SPSS-X 3.0.*, New York: Fischer, Stuttgart

van Vliet RCJA, Lamers LM (1998) *The high cost of death: should health plans get higher payments when members die?.* Medical Care **36**: 1451--1460

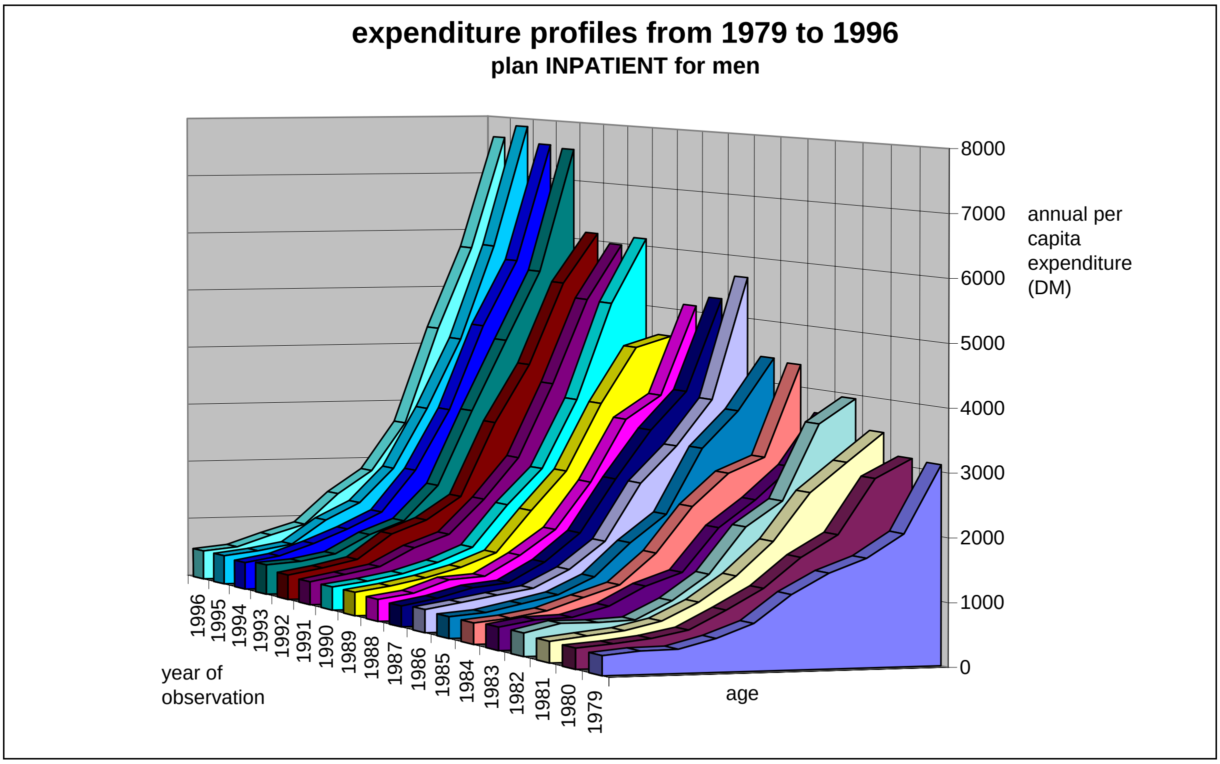
Figures and Tables

Figure 1 : Expenditure profiles of total expenditure 1996



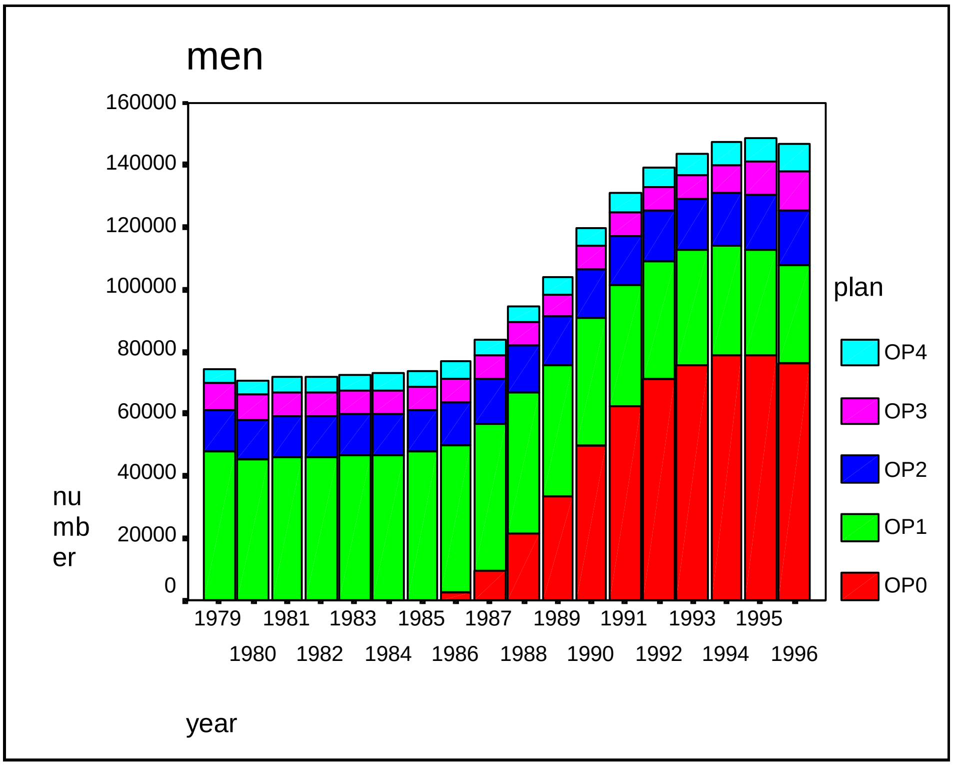
Source: own calculations

Figure 2: Steeping for the health plan INPATIENT



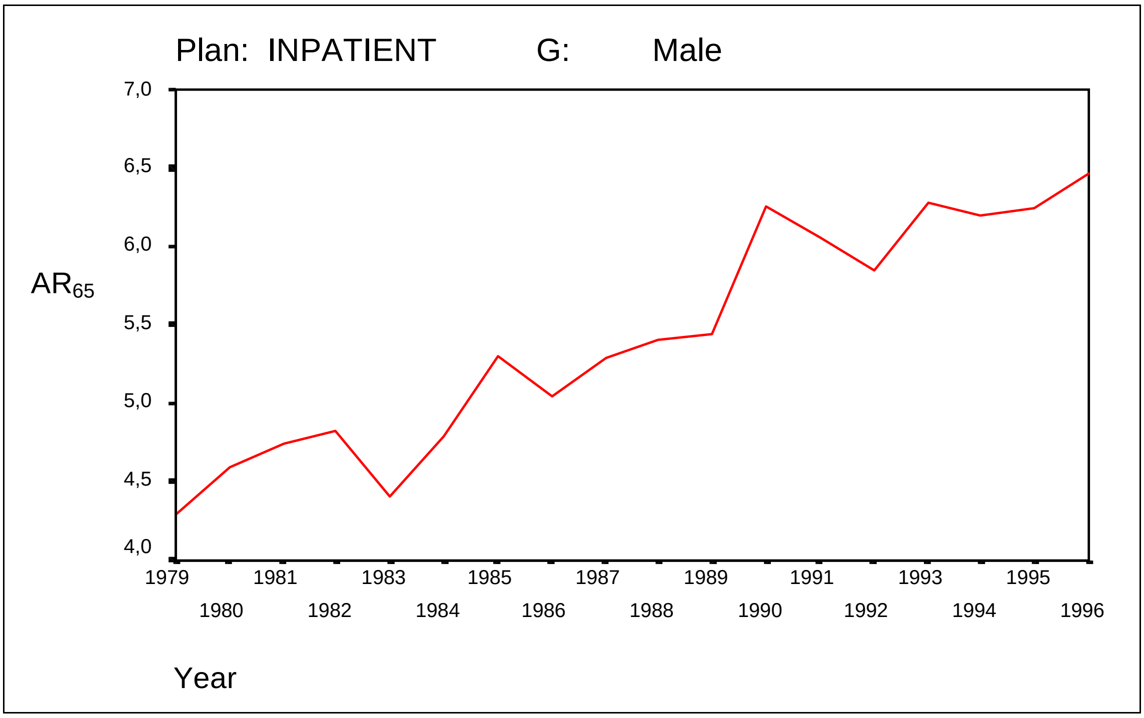
Source: own calculations

Figure 3: Trend in then number of insured in the system of outpatien health plans for men



Source: own calculations

Figure 4: Age cut method



Source: own calculations

Figure 5: Age group specific expenditure increase

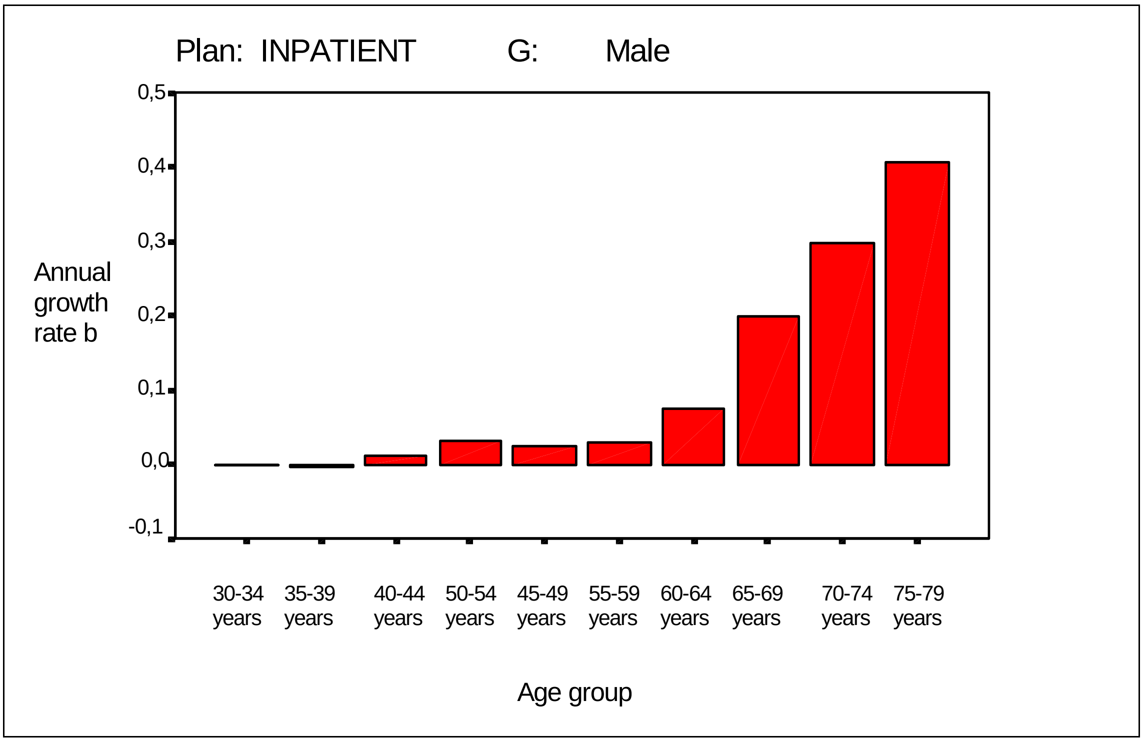


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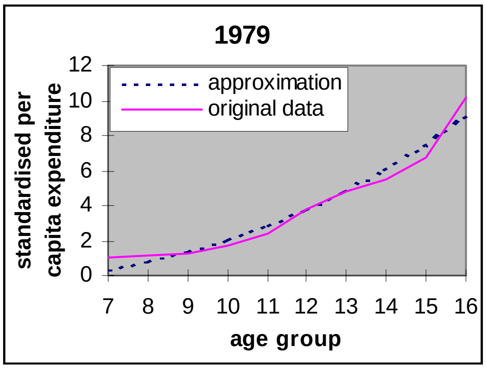
Figure 6: Approximation of expenditure profiles



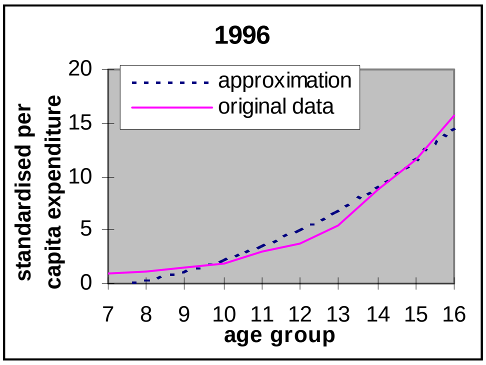


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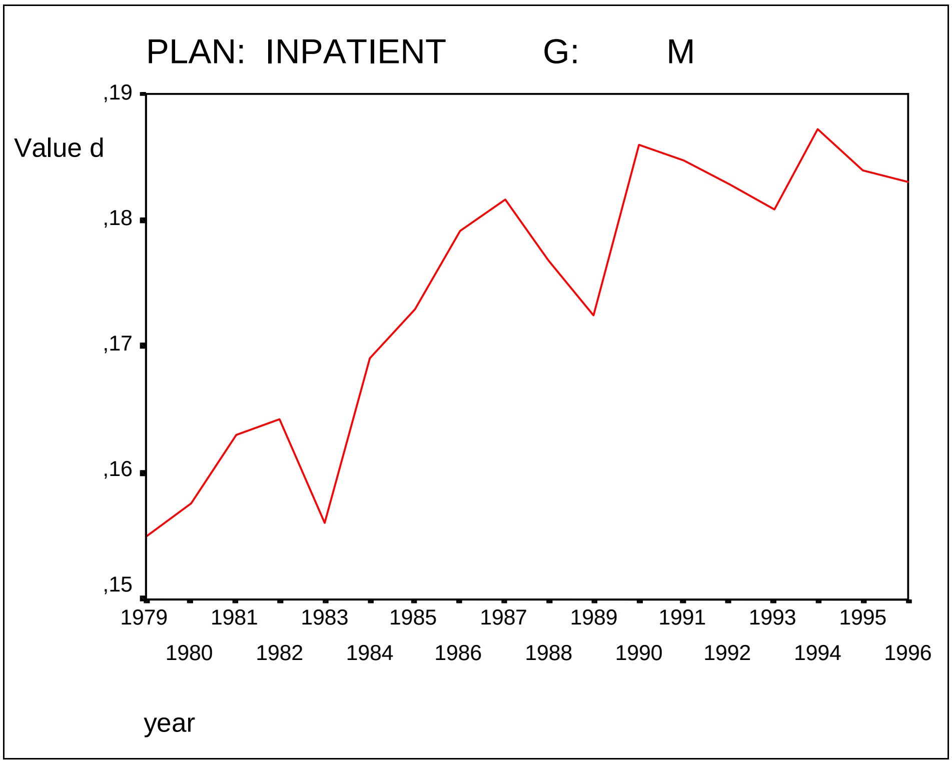
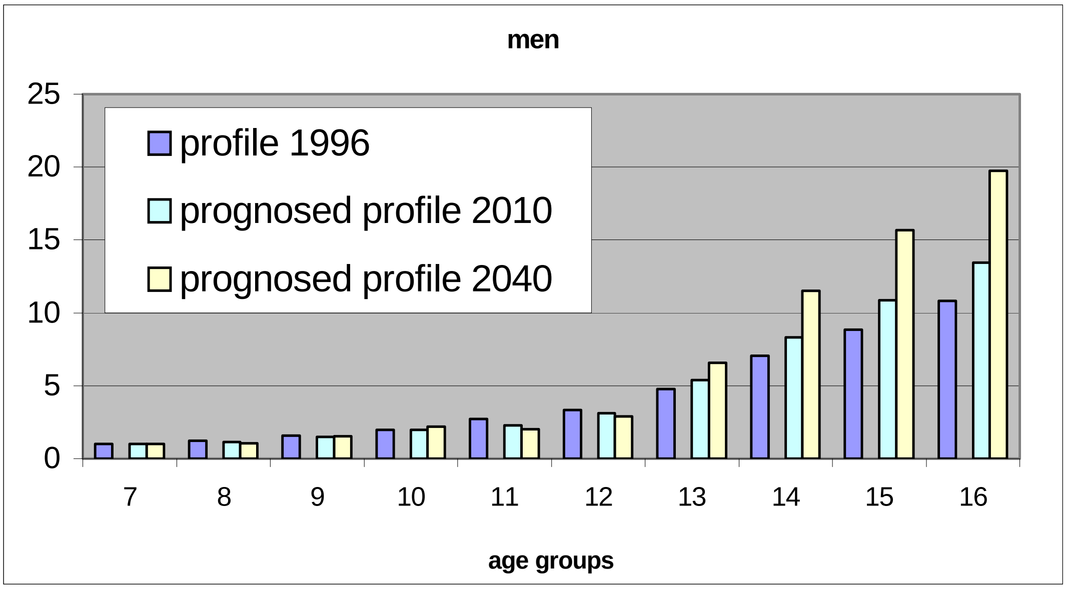
Figure 7: Exponential profile modelling



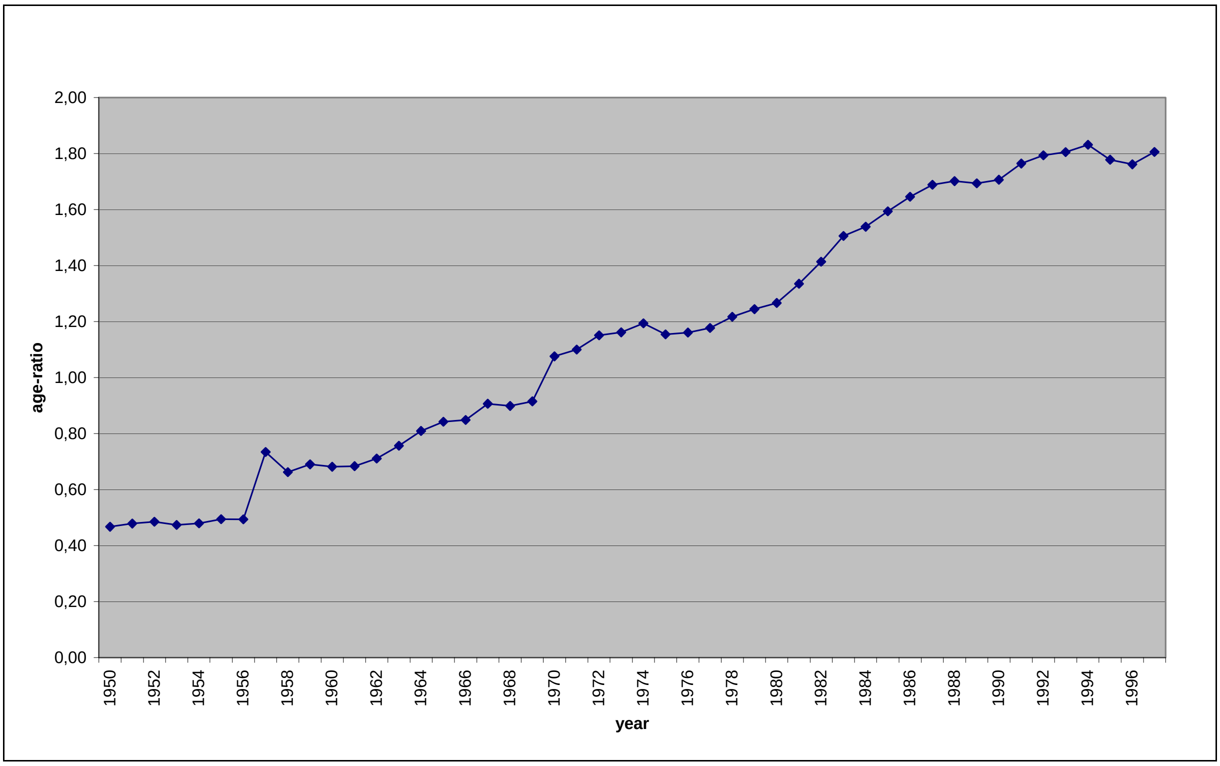
Source: own calculations

Figure 8: Forecasted standardised dised profiles



Source: own calculations

Figure 9: Trend of the "age-ratio" (per capita expenditure of "pensioners" to "non-pensioners") in the public health insurance system



Source: own calculations

Tables:

Table 1: Number of insured accordings to health plans in 1996

health plan	men	women	sum
OUTPATIENT1	31561	15097	46658
OUTPATIENT2	17778	9306	27084
INPATIENT	131251	56582	187833
SUPPLEMENTARY	265496	364044	629540

Source: Own calculations

Table 2: Results of steeping measurement: Age cut method

plan	gender	AR_{65}	
		1979	1996
OUTPATIENT1	male	3,49	3,68
OUTPATIENT1	female	2,02	2,62
OUTPATIENT2	male	3,30	5,06
OUTPATIENT2	female	2,17	3,12
INPATIENT	male	4,30	6,53
INPATIENT	female	3,00	4,63
SUPPLEMENTARY	male	4,11	5,83
SUPPLEMENTARY	female	2,18	3,77

source: own calculations

Table 3: Results of steeping measurement: EPM method

plan	gender	d	
		1979	1996
OUTPATIENT1	male	0,1297	0,1642
OUTPATIENT1	female	0,0670	0,0855
OUTPATIENT2	male	0,1627	0,1672
OUTPATIENT2	female	0,0819	0,0955
INPATIENT	male	0,1550	0,1830
INPATIENT	female	0,0809	0,1110
SUPPLEMENTARY	male	0,1374	0,1854
SUPPLEMENTARY	female	0,0619	0,0999

source: own calculations

Table 4: Results of the prognosis

	increase in total expenditure in %	increase in per capita exp. in %	increase in contribution rate in % of income
2010			
whole effect	30%	31%	2,9%
pure steeping effect	15%	15%	2,0%
pure demographic effect	13%	14%	0,9%
2040			
whole effect	92%	128%	12,9%
pure steeping effect	57%	57%	7,6%
pure demographic effect	23%	46%	3,4%

source: own calculations