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Terminal costs, improved life expectancy and future public health expenditure

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Abstract This paper presents an empirical analysis of public health expenditure on individuals in Denmark. The analysis separates out the individual effects of age and proximity to death (reflecting terminal costs of dying) and employs unique micro data from the period 2000 to 2009, covering a random sample of 10% of the Danish population. Health expenditure includes treatment in hospitals, subsidies to prescribed medication and health care provided by general practitioners and specialists and covers about 80% of public health care expenditure on individuals. The results confirm findings from previous studies showing that proximity to death has a significant impact on health care expenditure. However, it is also found that cohort effects (the baby boom generation) as well as improvements in life expectancy have a substantial effect on future health care expenditure even when proximity to death is controlled for. These results are obtained by combining the empirical estimates with a long term population forecast. When life expectancy increases, terminal costs are postponed but the increases in health expenditure that follow from longer life expectancy are not as large as the increase in the number of elderly persons would suggest (due to "healthy ageing"). Based on the empirical estimates, healthy ageing is expected to reduce the impact of increased life expectancy on real health expenditure by 50% compared to a situation without healthy ageing.

Keywords Public health expenditure forecast · Healthy ageing · Cost of dying · Two-part model

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T. B. Bjørner (✉) · S. Arnberg
Danish Economic Councils, Amaliegade 44, 1256 Copenhagen K, Denmark
e-mail: tbb@dors.dk

S. Arnberg
e-mail: sar@dors.dk

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Introduction

The ageing of the population is generally expected to increase future health care expenditure. In countries where the health care system is primarily financed by taxes this is expected to put pressure on long term fiscal sustainability, both because of the pressure on public health care expenses and because the share of the population that is active in the labour market will drop.

A number of studies suggest that ageing may have a lower impact on health care expenditure than previously believed. It was already observed by Getzen (1992) that the share of older people within the OECD countries did not appear to have a significant impact on per capita health cost expenditure. This seemed to be in contrast to results from micro studies showing a strong correlation between health cost expenditure and age. More recent studies using panel data confirm that ageing has a lower impact on health care expenditure than previously believed. One line of studies has demonstrated that health care expenditure is particularly high close to death (terminal costs), see e.g. Felder et al. (2000) and Hoover et al. (2002). As mortality increases with age, the correlation between health care expenditure and age may simply reflect that higher terminal costs are observed for an increasing share of a cohort as it gets older. Zweifel et al. (1999) found that age was insignificant as an explanatory variable for individual health care expenditure when they also included variables for the proximity to death of the individuals in their sample. This led Zweifel et al. (1999) to conclude that the thesis that increased health care expenditure is due to ageing is a "red herring". A number of subsequent studies have confirmed that proximity to death is the driving force for health expenditure, though it is generally found that age also appears to have a positive impact on health expenditure, even after accounting for proximity to death, see Häkkinen et al. (2008), Zweifel et al. (2004), Seshamani and Gray (2004a) and Seshamani and Gray (2004b).

A methodological problem of these studies relates to the direction of causality. On the one hand, proximity to death is likely to influence health expenditure as terminal illness is likely to result in expensive hospital admissions. However, the resources put into the treatment may, on the other hand, postpone death. This is formalised in theoretical models on health capital (see Grossman 1972, 2000), where individuals choose their length of life by investments in health. As pointed out by Salas and Raftery (2001), this may lead to endogeneity bias. However, in a study using instrumental variables estimation Felder et al. (2010) found, that even though endogeneity cannot be formally rejected the size of the bias is small.

A number of the previous studies have been based on small and/or potentially non-representative samples of the population collected either from private health insurance databases (e.g. Zweifel et al. 1999; Felder et al. 2000; Werblow et al. 2007) or from hospital authorities (e.g. Seshamani and Gray 2004a,b). Hospital-based data only cover part of the health care expenditure and might only include individuals who have been admitted to hospital in a given period, which is likely to omit individuals with good health. Insurance-based data might potentially suffer from self-selection, caused either by selection mechanisms into different insurance companies or due to adverse selection (including more individuals with health problems than the general population).

The current article contributes to the literature in three ways. First, as opposed to most of the previous studies, estimation will be based on a random sample of a population so the estimation will not suffer from potential selection bias. The data that can be obtained from Danish administrative data bases contain information on most public health care expenditure and these data are generally considered to be of a high quality, see Frank (2000). Second, we examine the importance of terminal costs for different age groups. Third, the empirical results are combined with a long term population forecast in order to quantify the effects of increased life expectancy in the presence of terminal costs. It is found that, when taking terminal costs into account, the impact of increased life expectancy on real health expenditure is reduced by about 50% compared to a naïve forecast that does not control for the effect of terminal costs.

In the next section we describe the data used and present descriptive statistics. The econometric model is described in "Empirical model" section, while estimation results are described in "Estimation results" section. In "The effect of reduced mortality on the age distributed health expenditure" section we forecast the impact of increased life expectancy on future health expenditure in Denmark. "Summary and conclusion" section concludes.

Data

The data contains information about public health care expenditures. Public health expenditure accounts for about 85% of the total consumption of health services in Denmark, see the Danish Economic Councils (2009). From a public finance perspective the public health expenditure is also especially interesting.

We use data on public health expenditure for the period 2000 to 2003 obtained by merging administrative data from Statistics Denmark and the Danish National Board of Health. Information on time of death was obtained from the *Danish Cause-of-Death Registry*, which contains information on time of death up to 1 January 2009.

We have obtained information on public health expenditure related to treatments at hospitals, by doctors, and for out-of-hospital prescription drugs from the following sources:

- The *Danish National Patient Registry* (Landspatientregisteret) contains information on all contacts between patients and public hospitals in Denmark. The DRG (Diagnoses Related Grouping) rates for somatic patients and DAGS (Danish Ambulant Grouping System) rates for ambulant patients are average cost rates which were used to calculate the resource cost at the individual level.
- Information on psychiatric hospital treatments at the individual level were obtained from the *Danish Psychiatric Central Research Register* and merged with information on the average cost per admission day and per ambulatory treatment.
- *The National Health Insurance Service Registry* contains information on health services, paid by the National Health Insurance Service, which are provided to Danish citizens by general practitioners, practicing specialists, dentists, physiotherapists, psychologists etc.
- The *Register of Medicinal Product Statistics* contains detailed information on the sales of all out-of-hospital prescription drugs. Information includes sales prices and public subsidies.

Together the merged database contains information on about 80% of the public health expenditure for the entire Danish population.[1] In order to ease computation, the estimations pre-

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[1] The 20% of the public health expenditures not included in the database reflects partly that the DRG and DAGS rates do not fully cover all public hospital expenditures (like buildings and medical equipment) and partly that a number of health care services performed by local municipalities are not included in the data.

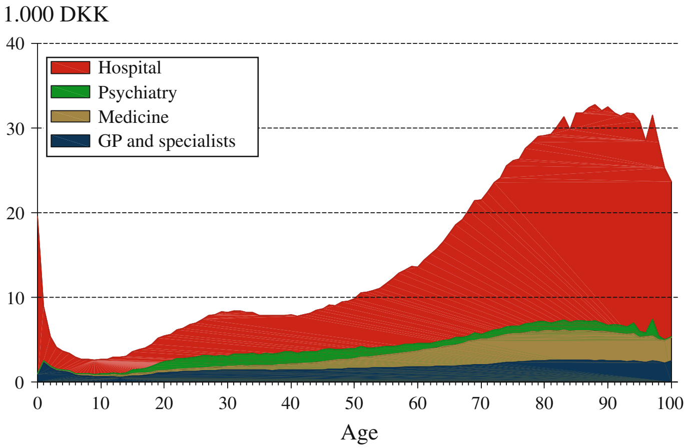

Fig. 1 Average public health expenditure per person in 2000. *Note* 2006 price level. In 2006 one Euro was equal to 7.46 DKK

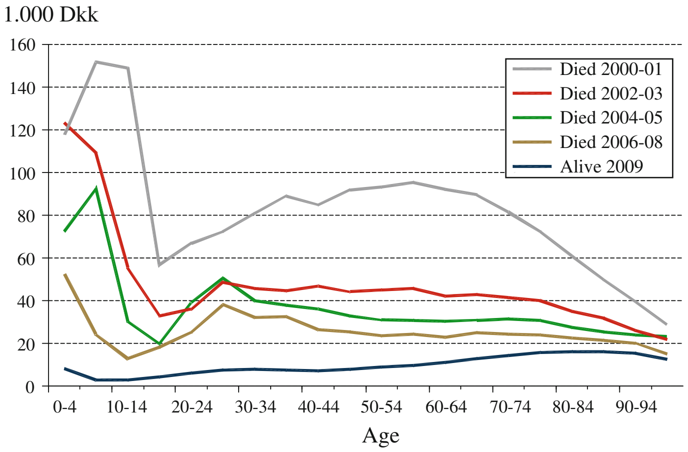

Fig. 2 Average public health expenditure per person in 2000 for individuals with different distances to death. *Note* 2006 price level. Average for 5-years of age intervals

sented in "Estimation results" section are based on a 10 per cent random sample of the Danish population (about 500,000 individuals a year).

The average annual public health expenditure per person in Denmark at different ages is illustrated in Fig. 1. It appears from the figure that health expenditure is relatively high for newborns. There is a small peak around the age of 30, which is explained by the high cost of women giving birth. The average health expenditure rises sharply around the age of 60, peaks in the 80'ies and drops somewhat after the age of 90 years. Similar patterns of health expenditure over the life cycle can be found in other countries, see OECD (2006).

Health expenditure up to death is very high across different age groups. This is illustrated in Fig. 2, which shows the mean average health expenditure in 2,000 at different ages but now divided between individuals with different remaining lifetimes. The figure clearly demonstrates that health expenditure increases with proximity to death (indicator of health status).

The lowest (blue) line in Fig. 2 is the health expenditure in 2,000 on individuals still living at the start of 2009. It appears from this line that age per se has some, though limited, impact on the average health expenditure. The implication is that the age increasing pattern of the health expenditure seen in Fig. 1 is partly driven by the higher mortality of the elderly; see Zweifel et al. (1999).

Figure 2 also demonstrates that terminal costs are very high for children and that there is a downward "kink" in the terminal costs around the age of 70.[2] There are different potential explanations for this. One explanation is that society (or the public health sector) puts a high value on the lives of young and a low value of the lives of the oldest. Another potential explanation is that it may be difficult to carry out a number of treatments with success on the old and relatively weak. Finally, differences in the cause of death for different age groups may also influence terminal costs. As an example, about half of the deaths among the 15–19 year olds in Denmark in 2000 were caused by suicide or traffic and other accidents. This may be the explanation for the relatively low terminal costs of this age group.

Empirical model

Our aim is to estimate a model of public health care expenditure as a function of demographic characteristics available in Danish population forecasts in order to use the model to predict the demographic driven pressure on future health care expenditure.[3]

Let HE_{it} denote public health expenditure on individual i in year t. For about 6% of the observations, public health expenditure in a given year is zero. To account for these observations we use a two-part model with a probit regression describing the likelihood of having positive health expenditure as a function of demographic characteristics (including variables for proximity to death), and a linear regression describing public health expenditure as a function of the same characteristics.

The variable HE_{it} is highly skewed to the right, as health expenditure on individuals affected by serious illness is very large. Right-skewed dependent variables are often dealt with by performing a standard estimation on the log transformed dependent variable. However, it was chosen instead to estimate the second part of the two-part model as a generalized linear model (GLM) using a log link, see Seshamani and Gray (2004a) and Manning and Mullahy (2001). The two-part model is given below, where X_{it} is a vector of explanatory variables, $E\,[\bullet]$ denotes expected values andΦ is the cumulative standardized normal distribution.

$$P(HE_{it} > 0) = P(\mathbf{X}'\boldsymbol{\gamma}_{it} + \nu_{it}) = \Phi(\mathbf{X}'\boldsymbol{\gamma}_{it}) \tag{1}$$

$$Ln\,[E\,[HE_{it}|\mathbf{X}_{it};\, HE_{it} > 0]] = \mathbf{X}'_{it}\boldsymbol{\beta}, \qquad HE_{it} \sim Poisson \tag{2}$$

The GLM estimation was preferred to the usual OLS estimation of $\log(HE_{it})$ because of the retransformation problems, i.e. obtaining a prediction of HE_{it} from the prediction of $\log(HE_{it})$. The standard retransformation method is Duan's smearing transformation method, see Duan (1983). The validity of this retransformation is based on the assumption of homoscedastic residuals from the OLS estimation. When there is heteroscedasticity, the smearing transformation method yields a biased prediction of the health expenditure. In our case homo-

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[2] Decreasing terminal cost for the oldest have also be found in studies based on data for America and other European countries, see e.g. Cutler and Sheiner (1998), Cutler (1999) and OECD (2006).

[3] Therefore we do not include a number of socioeconomic characteristics (e.g. education and income) which are not available in long term population forecasts.

scedasticity of the OLS residuals was rejected and a comparison of the observed and predicted health expenditure for different age intervals showed that the retransformation bias due to heteroscedasticity was far from being negligible.

The two-part model applied here has also been used in similar recent studies, see Häkkinen et al. (2008) and Seshamani and Gray (2004a). Some earlier studies applied a Heckman sample selection model instead of the simpler (but more restrictive) two-part model, which relies on the a priori assumption that the error term from Eqs. 1 and 2 are independent. The Heckman sample selection model may be preferred if it is possible to find regressors that predict the occurrence of positive health expenditure (both empirically and theoretically) in the probit regression but do not explain the size of the cost in Eq. 2. This is difficult when relying on demographic explanatory variables. In addition, it appears from other applications that the estimation of covariance between the error terms varies considerably when different estimation methods are applied; see Cameron and Trivedi (2005).[4]

Slightly simplified Eq. 2 was specified as follows (i and t are suppressed):

$$\begin{aligned} & Ln\left[E\left[HE_{it}|\mathbf{X}_{it};\,HE_{it}>0\right]\right]= \\ & \beta_0+\beta_1 A+\beta_2 A^2+\beta_3 A^3+\beta_4 S+\beta_5 S\cdot A+\beta_6 S\cdot A^2+\beta_7 S\cdot A^3+ \\ & \quad \sum_{j=0}^{4}\beta_{8+j}DB(j)+\sum_{c=1}^{4}\beta_{12+c}DF(c)+\sum_{k=1}^{6}\beta_{16+k}AD(k-1,k) \\ & \quad \beta_{23}D2000+\beta_{24}D2001+\beta_{25}D2002+u_{it} \qquad HE_{it}\sim Poisson \end{aligned} \tag{3}$$

where A is age and S is a sex dummy (S=1 for women). The first line of (3) determines health expenditure as a function of age and sex including interaction effects, which allows the impact of age to depend on sex. The first term in the second line takes into account that health expenditure is high in the first years of life, ($DB(j)$ are age dummies from the age of 0 to four years). The next term takes into account that health costs of women are relatively high during child bearing ages, ($DF(c)$ are dummy variables for women in the age intervals 20–24, 25–29, 30–34 and 35–39. The effect of proximity to death is measured by the dummy variables *AD(0,1)*…*AD(5,6),* where *AD(0,1)*=1 if the individual dies in the same year, *AD(1,2)*=1 if the individual dies within the following year etc. We include annual dummy variables (*D2000, D2001, D2002*) to control for annual effects across the individuals (2003 is the base case).

The inclusion of dummy variables for proximity to death is fairly standard in the literature separating the effect of age and terminal costs. However, this formulation assumes that the effect of proximity to death is the same for different age groups. This assumption is not supported by Fig. 2, which shows a downward "kink" in the terminal costs. The model should be made more flexible in order to take this kink into account.

One possible way to account for the kink would be by including interaction effects between age (or age intervals) and the variables for proximity to death. This may give a good description of the data covering a few years, but may give misleading results in a long term forecast where expected lifetime is assumed to increase as it has done historically. If terminal costs now start dropping around the age of 70, a forecast using interaction terms between proximity to death and age will (implicitly) assume that the kink also occurs at the same age in the future even though life expectancy is raised. This seems an unrealistic assumption. It seems more likely that the kink will depend on expected remaining lifetime—reflecting either that it may be difficult to treat patients successfully when they get closer to death or

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[4] A discussion of the pros and cons of the two-part model and the selection model can be found in e.g. Seshamani and Gray (2004b) and Salas and Raftery (2001).

that the health care sector is willing to invest less in patients as they approach their expected last years. Therefore, we model the kink as a function of remaining life expectancy.[5] To be more specific we include four dummy variables for low life expectancy (*DR0-3*, *DR3-6*, *DR6-11* and *DR11-16*), where, e.g., *DR0-3* indicates that life expectancy of the individual of a certain age and sex is between 0 and 3 years.[6] These four dummy variables are included in levels and as interaction terms with the six dummy variables of proximity to death. The same explanatory variables as described above were used to estimate the probit part of the model.

After estimation of the two-part model, the predicted health cost expenditure is given by:

$$E\left[HE_{it}|\mathbf{X}_{it}\right] = \exp\left[\mathbf{X}'_{it}\hat{\boldsymbol{\beta}}\right] \times E\left[P\left[HE_{it} > 0|\mathbf{X}_{it}\right]\right] \tag{4}$$

Estimation results

Estimation results are briefly presented in this section. However, it should be noted that it is difficult to interpret the estimated parameters directly because the overall effect depends both on the results from the probit and the GLM model and because a number of the explanatory variables are interacted and included in second or third order. In our comments to the estimation results we will focus on the results from the GLM model, as these are the main drivers of the overall results.[7] Detailed estimation results are shown in the table in Appendix.[8]

It appears from Appendix that all the proximity to death dummy variables are significant in the GLM model. As expected the parameters are decreasing with distance to death. It also appears that the parameter to the highest observed distance to death (individuals dies within 5 to 6 years) is well above zero and highly significant. This suggests that dummies for distance to death above 6 years should also be included in the model (if they had been available). Seshamani and Gray (2004a,b) also finds effects of distance to death longer than 6 years, while some other studies only find effects of distance to death for shorter periods, see e.g. Zweifel et al. (2004).

We obtain the expected results for the parameters on the interaction terms between proximity to death and the dummy variables for life expectancy. Proximity to death has a large effect on health expenditure, but for the oldest (with short life expectancy), the effect of proximity to death is reduced as was suggested in Fig. 2. As an example, the parameter on distance to death within one year is 2.34 in the GLM model (Appendix). For the oldest with expected remaining lifetime between 0 to 3 years there is a deduction in the parameter equal to 1.56 (the parameter on the AD01×DR0-3 interaction term in Appendix). Thus, the net effect of proximity to death 0–1 year for the oldest is 0.78.

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[5] It is, of course, ultimately an empirical question, whether the downward kink is determined by age or by remaining lifetime. But it requires individual health expenditure data for a rather long time period to empirically determine whether the kink in terminal costs is fixed at a certain age or whether it moves along with improvements in life expectancy. Estimation of an alternative model where the kink is determined by age instead of remaining lifetime do not have any impact on the "pure" age effect or other estimated parameters. However, the choice of model does have an impact on the long run prediction of the future health expenditures.

[6] Information on life expectancy was obtained from the Danish population forecast model described in Hansen and Barington (2009). In 2003 life expectancy was just below 16 years for a 65 year old male or 69 year old female, while life expectancy was less than 3 years for a 92 year old male or 95 year old female.

[7] This reflects that the share of individuals with positive public health expenditure in a given year is very high (about 94%).

[8] The estimation was carried out using STATA version 10.

Table 1 Predicted public health expenditure by age, sex and proximity to death

Age	Men			Women		
	Die 0–1 year 1,000 DKK	Die 3–4 year	Not died after 6 year	Die 0–1 year	Die 3–4 year	Not died after 6 year
10	39.5	14.5	3.5	37.3	13.9	3.3
20	48.6	18.0	4.3	76.3	30.6	7.2
30	61.9	23.3	5.6	113.7	45.7	10.8
40	79.0	30.2	7.2	91.8	36.5	8.6
50	98.2	38.0	9.0	110.9	44.3	10.5
60	115.9	45.1	10.7	124.4	49.7	11.7
70	102.0	40.1	16.4	102.3	41.2	16.9
80	82.7	38.8	19.5	78.2	37.0	18.7
90	58.0	30.3	19.4	52.5	27.6	17.7
100	33.7	21.0	14.6	30.0	18.7	13.0

The effect of other (not shown) age related variables (such as the dummy variables taking into account that health expenditure is relatively high for women when they give birth) are also included in the predictions. Health expenditure is measured in 2006 price levels but based on the health service level from 2003

To ease interpretation of the results, the predicted public health expenditure for individuals of different ages, sex and proximities to death are shown in Table 1. The columns headed "Not died after 6 year" show the predicted health expenditure for the surviving individuals who had not died 5–6 years after the health expenditure was observed. With the given specification (and data limitation) these columns can be interpreted as the pure age effect. It appears that age still has some effect on health expenditure, even after accounting for proximity to death. As an example, the predicted public health cost expenditure for a 30-year old male not dying within 6 years is 5,600 DKK per year, while the corresponding amount for an 80-year old is 19,500.

The predicted public health expenditure on an individual dying within a year is approximately 11 times higher than the public health expenditure on a survivor up to the age of 60. At higher ages the relative difference in health expenditure between persons dying and surviving (for at least 6 years) is reduced.

In Fig. 3 the predicted and average observed public health expenditure at different ages is compared. It appears that there is a reasonably good correspondence between the predicted and observed health expenditures, except at very high ages (this is probably due to the relatively low number of observations, especially for old men).

The lowest (green) curves in Fig. 3 show the part of the predicted health expenditure that can be attributed to the "pure" age effect, which is the health expenditure on individuals not dying within 6 years of the time of the observation of the expenditure. Up to the age of about 40, the health cost expenditure is almost identical to the health expenditure, which can be attributed to the age effect. This reflects that mortality rates are small for children and the young, and therefore the terminal costs, on average, have very little importance.

The effect of reduced mortality on the age distributed health expenditure

In the above section the public health expenditure on an individual was estimated as a function of age, sex and proximity to death, and it was illustrated that terminal costs account

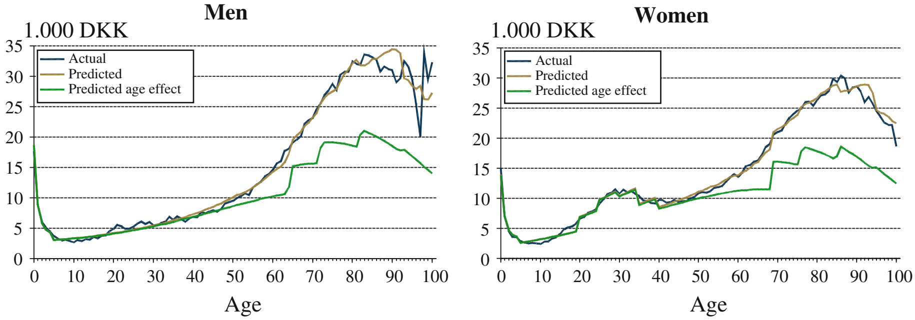

Fig. 3 Observed and predicted public health expenditure. *Note* Public health expenditure in 2006 prices, but at the expenditure (service) level in 2003. The "predicted age effect" calculated by assuming that all proximity to death dummy variables are equal to zero

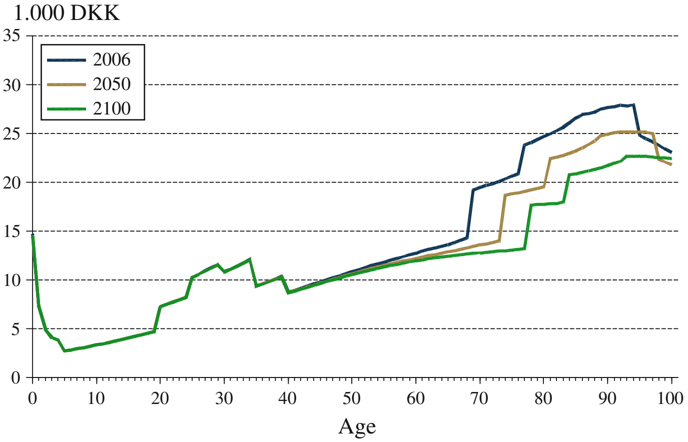

Fig. 4 Predicted future annual public health expenditure on females. *Note* Public health expenditure in 2006 price level (with a health service level corresponding to 2003). In 2006 one Euro was equal to 7.46 DKK

for a fairly large share of the overall health expenditure on the elderly. In this section we will analyse the effect of improved life expectancy and other demographic changes on future health expenditure. This is done by combining estimation results with the Danish population forecast presented in Hansen and Barington (2009).

First we calculate future expected average age distributed health expenditure by replacing the observed proximity to death dummies with the forecasted probabilities that a person of a given age will die within one year, within one to two years and so forth. In 2006 the risk of dying within a year for an 85-year old female was 8.3%. In 2050 and 2100 the mortality rate is projected to drop to 5.3 and 3.2.

The predicted annual age distributed public health expenditure per female in 2006, 2050 and 2100 is illustrated in Fig. 4. As illustrated the increased life expectancy will mainly influence the expected health expenditure for the older age groups, where terminal costs account for a relatively high share of health expenditure. As an example, the predicted annual health expenditure on an 85-year old female is reduced by 13% from 2006 to 2050. From 2006 to 2100 the predicted reduction is 21%. The reduction in average health expenditure associated with reduced mortality and postponed terminal costs is generally referred to as "healthy age-

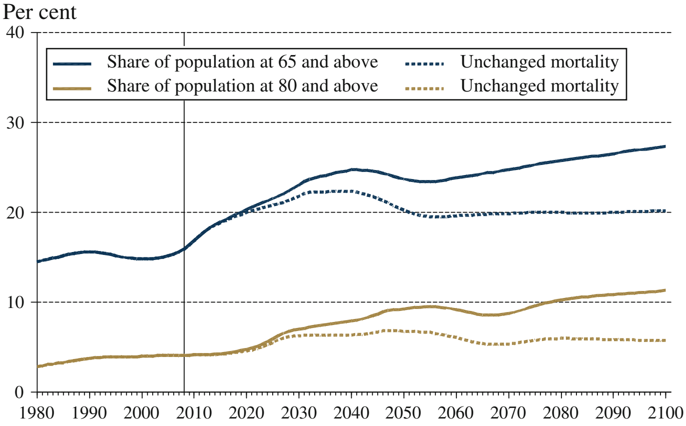

Fig. 5 Forecasted shares of elderly in Denmark. *Source* Danish population forecast from Hansen and Barington (2009)

ing". Likewise, the (unrealistic) scenario, where average health expenditure is constant when mortality is reduced is referred to as "unhealthy ageing".

Next the predicted age distributed public health expenditure per individual is combined with the predicted changes in the age distribution of the Danish population. In the next decades the share of the elderly in the total population is expected to increase drastically. This is illustrated in Fig. 5, which shows the predicted shares of the population being at least 65 and 80 years old. The increase in the share of the elderly can partly be attributed to the improved life expectancy and partly to cohort effects, as the large cohorts born just after the Second World War are now becoming elderly.

Before we turn to the effect of ageing on public health expenditure, it is instructive to consider the relative importance of cohort effects and improvements in life expectancy. In order to illustrate the relative impact of the cohort effects and the improved life expectancy Fig. 5 also illustrates the changes in the shares of the elderly assuming that the mortality rates are constant (i.e. no improvement in life expectancy). This shows the contributions of the cohort effects, which are illustrated by the dotted lines in Fig. 5. The additional increase in the overall share of the elderly—the increase from the dotted to the solid lines—can be attributed to the improvements in life expectancy.

The impacts of demographic changes and healthy ageing on future public health expenditure are affected by the following three effects: (i) The cohort effect, which up to the middle of the century contributes to an increase in the number of elderly, (ii) the effect of improved life expectancy, which means that the elderly will require public health services for a longer period, and (iii) the effect of healthy ageing, which will partly reduce the impact of the improved life expectancy.

The magnitudes of these three effects are illustrated in Fig. 6. If it is assumed again that mortality is not reduced, predicted health expenditure is as shown by the red line in the figure. Here the increase in health expenditure solely reflects the cohort effects. In addition to the cohort effects, improvements in life expectancy will contribute to an increase in health expenditure due to a further increase in the number of elderly. The joint effect of this is shown by the top (grey) line in Fig. 6 subject to the assumption that the average public health expenditure per person does not change (unhealthy ageing). Finally, when healthy ageing is taken into account (green line) the effect of improved life expectancy is roughly halved.

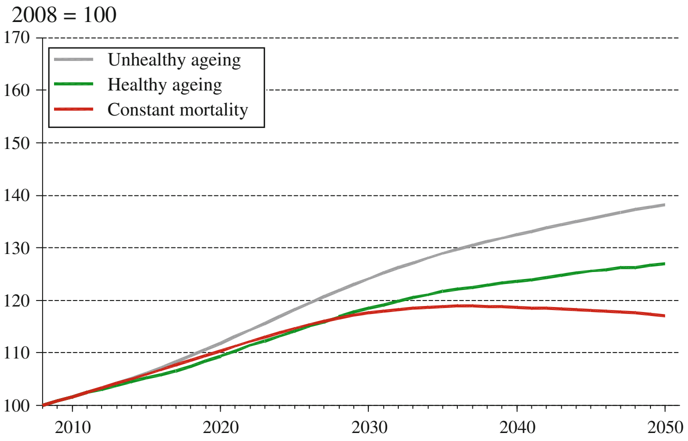

Fig. 6 The contribution of ageing to public health expenditure

The overall effect of ageing on public health expenditure will be an increase of 27% from 2008 to 2050. Of this increase 17% points can be attributed to cohort effects, while the last 10% points can be attributed to the improvements in life expectancy (after correcting for healthy ageing).

The increase in public health expenditure of 27% from 2008 to 2050 caused by demographic changes corresponds to an increase in the share of public health expenditure from 6.8% of GDP in 2008 to 8.5% in 2050.[9] This increase only includes the impact of demographic changes on the expenditure. Future public health expenditure is also likely to be influenced by a number of other factors such as the income demand elasticity for health services and the growth in productivity of producing health services relative to overall growth in productivity. Generally, growth in health expenditure has been higher than overall economic growth, even after accounting for demographic factors. In Denmark the average annual growth in public health expenditure has exceeded growth in GDP by about 0.3% points during the last 15 years after controlling for the impact of demographic changes, see Hansen and Pedersen (2010) and Danish Economic Councils (2009). If we make the heroic assumption that public health expenditure will continue to exceed annual growth in GDP by 0.3% points until 2050, then public health expenditure will increase further to 9.6% of GDP in 2050 (instead of the increase from 6.8 to 8.5). Thus, with the given assumption of excess growth in public health expenditure, it appears that most of the future increase in health expenditure derives from demographic changes.

Summary and conclusion

In the next decades the number of elderly will be increasing in Denmark as well as in most other European countries. The increase is caused partly by cohort effects and partly by improved life expectancy. In this paper we have estimated the impact of age and proximity to

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[9] The forecasts for Danish GDP were obtained from the DREAM model, which is a long term dynamic computable general equilibrium model with overlapping generations of households. As part of the DREAM model system a model for population forecasting is integrated (the same population forecast a used when calculating future health expenditure). The forecast is documented in DREAM (2009), and further documentation of the calculations on health expenditure can be found in Danish Economic Councils (2009).

death on public health expenditure on individuals using a unique dataset covering a random sample of 10% of the Danish population.

The estimations confirm results from previous studies that proximity to death has a significant impact on the health costs of an individual due to high terminal costs. When life expectancy increases, the terminal costs are postponed, but the increase in public health expenditure is not as large as the increase in the number of elderly persons would suggest in a naïve forecast that does not take into account that a part of health expenditure is terminal costs experienced only once in a lifetime. However, the results also suggest that age does influence health costs, even after indicators of proximity to death are included in the empirical model.

The estimation results were combined with a long term population forecast in order to predict the impact of demographic changes on public health expenditure. It appeared from the forecast that the impact of increased life expectancy on health expenditure is about twice as high in a naïve model that does not take terminal costs and healthy ageing into account, compared with a model that corrects for this. However, in the next decades the large cohorts—not improvements in life expectancy—will be the most important demographic driver leading to pressure on increasing public health expenditure.

The forecast also shows that healthy ageing only reduces—not removes—the growth in demographically driven health expenditure. From 2008 to 2050 ageing appears to increase public health expenditure by 27%, which corresponds to an increase in the share of public health expenditure from 6.8 to 8.5% of GDP in 2050. Non demographic factors, such as high income elasticity for health services, are likely to lead to an additional increase in public health expenditure. However, demographic changes appear to be the primary driver of increased health expenditure in the next decades.

The forecasted increases in health expenditure are likely to put pressure on public expenditure and on the sustainability of fiscal policy. This leaves politicians with a couple of unattractive options. One option is to increase taxes. Income taxes are already high in Denmark and a further increase is likely to lead to large tax distortions. Other options are to reduce public health service levels or increase direct user pay. This may be unattractive due to distributional concerns.

Appendix: Estimation results from the two-part model of public health expenditure

See Table 2.

Table 2 Estimation of public health expenditure for the period 2000 to 2003

Variables	GLM model		Probit	
	Estimate	t-value	Estimate	t-value
Age	0.01**	5.7	−0.01**	−13.0
$Age^2/1000$	0.39**	7.6	0.78**	25.1
$Age^3/1000000$	−4.15**	−11.0	−7.38**	−25.7
Female	−0.27**	−12.2	−0.20**	−17.3
Female × age	0.02**	11.4	0.03**	26.2
Female × $age^2/1000$	−0.44**	−8.3	−0.55**	−15.6
Female × $age^3/1000000$	2.13**	5.9	2.30**	8.6

Table 2 continued

Variables	GLM model		Probit	
	Estimate	t-value	Estimate	t-value
0-year old	1.81**	66.1	0.30**	21.9
1-year old	0.98**	32.0	1.83**	40.9
2-year old	0.55**	20.1	1.60**	47.3
3-year old	0.34**	6.5	1.19**	53.2
4-year old	0.24**	5.6	1.00**	52.9
Female 20–24 year	0.35**	16.9	0.62**	44.7
Female 25–29 year	0.54**	31.3	0.54**	40.9
Female 30–34 year	0.45**	28.9	0.42**	33.5
Female 35–39 year	0.18**	12.0	0.27**	23.6
Die within 0–1 year (AD01)	2.34**	123.0	0.49**	10.7
Die within 1–2 year (AD12)	2.21**	91.9	0.11**	3.2
Die within 2–3 year (AD23)	1.71**	62.9	−0.02	−0.7
Die within 3–4 year (AD34)	1.45**	47.9	−0.08**	−2.8
Die within 4–5 year (AD45)	1.28**	41.9	−0.11**	−4.1
Die within 5–6 year (AD56)	1.15**	35.5	−0.02	−0.8
Life expectancy 0–3 years (DR0-3)	0.63**	6.2	1.27**	10.7
Life expectancy 3–6 years (DR3-6)	0.62**	20.3	0.83**	21.8
Life expectancy 6–11 years (DR6-11)	0.50**	28.5	0.39**	19.5
Life expectancy 11–16 years (DR11-16)	0.33**	27.0	0.08**	7.2
AD01 × DR0-3	−1.56**	−15.2		
AD01 × DR3-6	−1.29**	−45.5		
AD01 × DR0-6			0.58**	5.7
AD01 × DR6-11	−0.94**	−38.6	0.38**	4.7
AD01 × DR11-16	−0.56**	−20.2	0.33**	3.5
AD12 × DR0-3	−1.66**	−15.5	0.35*	2.2
AD12 × DR3-6	−1.44**	−41.6	0.44**	6.7
AD12 × DR6-11	−1.06**	−34.8	0.28**	5.5
AD12 × DR11-16	−0.68**	−19.2	0.13*	2.4
AD23 × DR0-3	−1.32**	−11.3	0.37*	2.3
AD23 × DR3-6	−1.17**	−31.0	0.30**	5.4
AD23 × DR6-11	−0.88**	−25.7	0.24**	5.2
AD23 × DR11-16	−0.61**	−14.9	0.10*	2.0
AD34 × DR0-3	−1.11**	−8.9	0.37*	2.1
AD34 × DR3-6	−1.01**	−24.8	0.21**	4.0
AD34 × DR6-11	−0.77**	−20.5	0.24**	5.6
AD34 × DR11-16	−0.55**	−12.6	0.07	1.4
AD45 × DR0-3	−1.00**	−7.4	0.20	1.1
AD45 × DR3-6	−0.94**	−22.0	0.21**	4.0
AD45 × DR6-11	−0.74**	−19.5	0.21**	5.1

Table 2 continued

	GLM model		Probit	
Variables	Estimate	t-value	Estimate	t-value
AD45×DR11-16	−0.45**	−9.9	0.09*	2.1
AD56×DR0-3	−0.94**	−6.6	0.18	0.8
AD56×DR3-6	−0.92**	−20.7	0.05	0.9
AD56×DR6-11	−0.71**	−17.9	0.06	1.5
AD56×DR11-16	−0.49**	−10.3	0.02	0.4
Year 2000	−0.10**	−15.3	−0.02**	−5.5
Year 2001	−0.07**	−10.4	−4.27E-03	−1.1
Year 2002	−0.03**	−4.9	−8.38E-03*	−2.1
Constant	8.15**	360.5	1.16**	123.5
Number of observations	1,996,332		2,122,823	
Pseudo R^2	0.201		0.071	

A distance to death above 6 years (survivor) is the base case for the proximity to death dummy variables. Year 2003 is the base case for the year dummies. ** Indicates significance at the 1% level, while * is significance at the 5% level (robust standard errors)

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