How does end of life costs and increases in life expectancy affect projections of future hospital spending?

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ABSTRACT

This article examines the extent to which differences in life-expectancy are associated with shifts in average hospital costs for different age groups. The size of the shift is important because it makes a large difference to the importance of demographic factors when projecting future health expenditures. The effect of increases in life expectancy on the cost curves is identified by comparing two countries with different life expectancies, but which are very similar on other variables like culture, technology and health systems (Norway and Denmark). Using data from the National Patient Registries the paper compares the ratio of average spending on individuals who die and individuals who survive in different age groups in these two countries. After controlling for cohort, the best fit between the age related cost curves is achieved when the cost curve in the country with a two year longer life expectancy is shifted by two years. For instance, seventy year olds in the country with the longest life expectancy have an everage cost ratio that is comparable to sixty-eight year olds in the country with the shorter life expectancy. This suggests that increases in life expectancy are associated with shifts in the cost curves and that the shift is proportional to the shift in life expectancy.

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1 Introduction

This article addresses the question of how increases in life expectancy affect health costs. Within this large general topic, the specific contribution in this article is an empirical test of the assumption that the age-profile of health costs shifts in proportion to changes in life expectancy, for instance that future seventy year olds will have health costs that are more similar to today's sixty-nine year olds. This is an important assumption because it makes a significant difference to the overall projection of future increases in health spending and the role of age as a driver of the spending growth. These projections, in turn, are used by policy makers in the debate about the need for health reforms and to plan the size of different types of health services.

The first section creates the formal framework for the discussion. It presents three different methods of cost projections and their assumptions in a unified framework – the naïve approach, the time to death approach and the shifting cost curve approach. The second section tests the assumption that increases in life expectancy will lead to proportional shifts in cost curves. Over time the age distribution of health spending may be affected by changes in technology, income, education and many other factors which make it difficult to isolate the effect of increases in life expectancy in longitudinal data. Given the problems with longitudinal data, the section explores an alternative identification strategy which compares the cost pattern in two countries with differing life expectancy. The comparison of the age related cost-patterns support the assumptions that shift in age-related cost curves are associated with change sin life expectancy. The third and final section discusses some possible weaknesses and extensions, including problems related to cross-country comparison of average hospital spending in different age groups.

2 Background and framework

2.1 The naïve approach

Historically the standard approach to predict the effect of demographic change on total health costs simply multiplied the expected number of people in different age groups by the current average costs in these age groups. Formally total cost (*TC*) in *t* years from the current year (t_0) is then:

$$TC_{t_0+t} = \sum^{a} n_{a,t_0+t}\, \bar{c}_{a,t_0}$$

Where n is the number of individuals in age group a in year t_0+t and $\bar{c}$ is the average cost of a person in age group a in year t_0+t.[1] Examples of studies which have used this method to estimate the changes in health spending due to demographic change include Strunk et al. (2006) and Polder et al. (2006).

The key assumption in the naïve method is that the future average cost of a seventy year old is equal to the average cost of seventy year olds today, or more generally that for all age groups (a):

$$\bar{c}_{a,t_0+t} = \bar{c}_{a,t_0}$$

Fuchs (1984) and others have pointed out that this assumption is unlikely to hold and in a seminal and much discussed article, Zweifel et al. (1999) tested the assumption using data

[1] Each gender is often treated separately when calculating costs but for the sake of notational simplicity gender is not made explicit in the equations.

from Swiss health insurers and argued that it was wrong: As life expectancy increases mortality among seventy year olds will decrease which, in turn, means that the average cost of seventy year olds will go down because it is during the last year(s) of life that costs are high. To see this formally, let superscript S and D indicate survivors and decedents i.e. n^S_{a,t_0} represents the number of people in an age group (a) who are alive for the whole year (t_0). Overall average health cost in an age group is the average cost of those who live the whole year ($\bar{c}^S_{a,t_0}$) and the average cost of those who die during the year ($\bar{c}^D_{a,t_0}$), weighted by the proportion of individuals who survive and die:

$$\bar{c}_{a,y} = \frac{n^S_{a,t_0}}{n^S_{a,t_0} + n^D_{a,t_0}} \bar{c}^S_{a,t_0} + \frac{n^D_{a,t_0}}{n^S_{a,t_0} + n^D_{a,t_0}} \bar{c}^D_{a,t_0}$$

When life expectancy increases, the proportion of individuals who die as seventy year olds will go down. As long as hospital spending is higher in the year of death than the other years ($\bar{c}^D_{a,t_0} > \bar{c}^S_{a,t_0}$) future spending is overestimated because it is based on an average that includes the costly end of life expenses of a larger share of individuals than we will have in the future in the same age group.

2.2 The time to death approach

In order to avoid the problem of overestimating the effect of increasing life expectancy on future health costs, an alternative approach would be to treat health costs that that are related to end of life separately. Instead of multiplying the number of individuals with average cost, a simple version of the time to death approach would multiply the expected number of deaths with the cost during the last year of life and the expected number of survivors with the cost for those surviving the whole year. This is done in each age group and the sum across the age groups represents total costs:

$$TC_{t_0+t} = \sum^{a} n^{D}_{a,t_0+t}\, \bar{c}^{D}_{a,t_0} + \sum^{a} n^{S}_{a,t_0+t}\, \bar{c}^{S}_{a,t_0}$$

Based on this and similar approaches, many authors have demonstrated that increases in life expectancy will not increase health spending as much as the naïve approach predicted. For instance, Stearns and Norton (2004) argue that taking time to death into account reduces the cost estimate by about thirty percent.

Although the time to death approach takes into account the fact that a large share of health spending typically occur towards the end of life, it still makes some assumptions about the size of these costs. Instead of assuming that the overall average costs stay the same, it assumes that the future health cost of end of life and survivors are equal to the current cost of dying and being alive in the same age group. For instance, the cost of dying for a seventy year old in the future is assumed to be the same as the current average cost of dying among seventy year olds. More generally it assumes that for all age groups:

$$\bar{c}^{D}_{a,t_0+t} = \bar{c}^{D}_{a,t_0}$$

$$\bar{c}^{S}_{a,t_0+t} = \bar{c}^{S}_{a,t_0}$$

This is an important assumption because several studies indicate that end of life costs decrease in old age (Brockmann 2002; Lubitz & Riley 1993; Polder et al. 2006). This, in turn, means that the end of life approach will predict a reduction in health care costs simply because more people die at an old age, when their last year – as measured by the current average costs pattern – is less costly. For predictions over a longer time horizon, the effect of this is quite strong since end of life costs tend to fall substantially as age increases. For instance, in data from the Netherlands the average cost of a ninety year old who dies was half of that of a seventy year old (Polder et al. 2006). A similar trend, but not as steep, is observed in US data (Lubitz et al. 1995). Moving a large share of the population into age categories where their last year of life is significantly less costly, will produce a large cost saving. The plausibility of this conclusion, however, depends on the realism of the assumption. Will age related survivor costs and end of life cost stay constant when life expectancy increases?

2.3 The healthy ageing approach

Some authors argue that total health care spending may be reduced when more people die at an older age. For instance, based on the cross-sectional evidence that end of life cost decrease as age increases Brockmann (2002) concludes that “there is reason to believe that health care expenditures may actually decrease with the prolongation of life …”. Lubitz and Riley (1993) also argue that “Because acute care costs are lower among persons dying at older ages [...] the percentage of Medicare payments spent on the last 12 months of life may be gradually declining.” After examining the data, however, they do not find that the share of end of life spending out of overall health spending has decreased over time.

Other authors argue that as life expectancy increases one would also expect the cost curves to shift. For instance, Breyer and Felder (2006) explore the method of “adjusting the age-specific expenditures rightward by the difference in age-specific life expectancies. For example, if the life expectancy of a sixty-five year old will increase by 4 years until 2050, we shall assume that a sixty-five year old in 2050 will only spend as much as a sixty-one year old today.” Similar approaches have been suggested and used by Madsen (2004a), (Martins 2005), Colombier and Weber (2011), and used in forecasts of health spending in the European Union (EC 2006).

To formalize an example of the shifting cost curve approach, assume the difference in the current life expectancy and the life expectancy in the future is a fixed number of years (Δe). For instance, if life expectancy goes up by two years, seventy year olds are assumed to be similar to current sixty-eight year olds when it comes to spending on those who die and stay alive:

$$\bar{c}^{D}_{a,t_0+t} = \bar{c}^{D}_{a-\Delta e,y}$$

$$\bar{c}^{S}_{a,t_0+t} = \bar{c}^{S}_{a-\Delta e,,t_0}$$

$$TC_{t_0+t} = \sum^{a} n^{D}_{a,t_0+t}\,\bar{c}^{D}_{a-\Delta e,t_0} + \sum^{a} n^{S}_{a,t_0+t}\,\bar{c}^{S}_{a-\Delta e,,t_0}$$

Unlike the end of life approach, the assumptions in the healthy ageing approach leads to the conclusion that future seventy year olds will consume less health resources than current seventy year olds to maintain the same level of health. Part of the reason for the improvement in health could be increased health spending at an earlier stage, but the assumption in the shifting curve approach is that health is also affected by factors other than health spending itself. The shift in the curve captures these exogenous factors and not the endogenous change that is due to increased spending. It is also important to note that the healthy ageing phenomenon is not only due to fewer people dying at a given age which is the key insight in the time to death approach. The healthy ageing perspective goes further than this and assumes that when people live longer on average, they will also be healthier at a given age. This is distinct from an improvement in an average health caused by only excluding those who are close to death.

Healthy ageing is often assumed to decrease future health costs compared to the naïve approach, but one should distinguish between the effect on the cost curves for survivors and those who die. If the assumption of healthy ageing is true seventy year olds be fit enough to may receive more aggressive end of life treatment than current seventy year olds. This will increase the end of life costs for some age groups. Because of this the healthy ageing approach does not predict a decrease in overall end of life cost when life expectancy increases and more people die at an older age. Theoretically the increased spending towards the end of life among previously old individuals is justified by both economic and medical arguments. In the economic approach end of life spending is the result of a rational investment in an uncertain outome. The gain from the investment is a function of the expected number of years remaining. An exogenous increase in life-expectancy will lead to a higher return on a health spending at a given age since there is – on average – a larger number of years to be gained if one survives. For this reason an exogenous increase in life expectancy will lead to a positive shift in the age related end of life cost curve.

The medical argument is less driven by calculations based on future effects, but relies on the assumption that increasing life expectancy improves health among the old and makes it possible to treat life-threatening diseases more aggressively, thus driving up the cost of end of life spending for those who die in an age group where average health has improved. In this sense, but with different justification, both the economic and the medical perspective would predict a shift in age-related end of life costs as life expectancy increases.

The predicted increase in health spending due to demographic changes should not be confused with an overall prediction of future health spending. Many other factors will change in the future and the spending on seventy year olds may increase as a result of these

(Smith et al. 2009), but when isolating the effect of age alone the assumption is that future seventy year olds will require fewer health resources than current seventy year old in order to maintain the same level of health. They may be richer, demand a higher standard and technology may improve to make new treatments available, but these factors are assumed constant when we isolate the effect of demographic factors.

The assumption used in the first two approaches to cost projection – the naïve approach and the time to death approach – have been widely discussed and tested in the so called "red herring debate" (Felder et al. 2010; Karlsson & Klohn 2013; Seshamani & Gray 2004; Stearns & Norton 2004; Werblow et al. 2007; Wong et al. 2011; Zweifel et al. 1999). In contrast, the assumption that increasing life expectancies will shift the cost curves has received less attention in the economic literature. There is a large medical and demographic literature on the related topics of compression of morbidity (Fries 2002; Miller 2001). There is also a related literature on the steepening of health costs over time (Felder & Werblow 2008), but in the literature on life expectancy and health costs the assumptions about the size of the shift in the age related cost curves are openly described as exploratory and "arbitrary" (Madsen 2004b; Raitano 2006). Given the relative lack of attention to this topic, and its importance for cost predictions, it seems justified to explore this assumption in more detail.

3 Testing the shifting hypothesis: Methods and data

3.1 Methods and data

To test the assumption of shifting cost curves as life expectancy increases one might use longitudinal data to examine whether end of life costs of a seventy year old today is more similar to the end of life cost of a sixty nine year old ten years ago than a seventy year old. Unfortunately, spending over time may be affected by many other factors in addition to increases in life expectancy: Changes in income, technology, reforms in the provision of care services, changing priorities and new systems of finance. Some of these factors also affect life expectancy which means that it is difficult to identify the effects of increased life expectancy on health spending by comparing the age distribution of health expenditures in longitudinal data. The problem is exacerbated by the fact that the key identifying conditions move in opposite directions over time. To reduce the influence of technology and other changes, it is preferable to compare changes within a short time window with few large technological changes. In contrast, to compare situations with significant differences in life expectancy it is preferable to compare time periods that are far apart. The larger the change in life expectancy, the more likely it is that other factors affect the spending pattern. The problems do not necessarily imply that it is impossible to use longitudinal data. For instance, Payne et al. (2009) have shown that average end of life costs at a given age tended to increase, and survivor cost decrease, in a ten year time window (1991-2001) using data from British Colombia in Canada. Similarly, van Baal and Wong (2012) have explored longitudinal data from the Netherlands between 1981 and 2001 and found that the age with the highest health spending increased over time. This indicates that there is a shifting effect, but the time window does not allow more precise estimation of how large the effect is when life expectancy changes more significantly.

Because of the difficulties of identifying the effects over time, we explore a different approach. The basic idea is to compare two populations which are as similar as possible with respect to the characteristics of the populations and the institutional environment, but which still differ significantly in life expectancy. These cases may be rare, and often one may suspect that the differences are caused by the same factors that confound the analysis of longitudinal data, but given the problems with longitudinal analysis it seems worthwhile to explore the cross-sectional approach if it is possible to find suitable countries that are similar on the variables one want to hold constant and different in terms of life expectancy.

In the tests below we use data from Norway and Denmark to examine the influence of life expectancy on spending patterns. Both countries have universal and free public health care, both countries share the same cultural and institutional background and both countries there are no large differences in access to the medical technology. At the same time there is one interesting difference: Life expectancy is two years lower in Denmark than in Norway (Chenet et al. 1996; Juel et al. 2000; OECD 2013).[2] This difference in life expectancy makes it interesting to explore whether the Norwegian age-related spending pattern resembles a shifted verison of the Danish, where the shift is some proportion of the difference in life expectancy. Comparing the two countries provides not only information on the validity of the shift hypothesis in itself, but also on the likely size of the shift in health spending curves relative to increases in life expectancy.

Both Norway and Denmark have national patient registries which makes it possible to identify end of life costs for different age and gender categories in a given year. After obtaining the required ethical and practical permissions to get the hospital records, we computed the cost of inpatient hospital treatment for different age and gender categories in Norway and Denmark for all individuals who who died in the two countries in 2009 (see Figure 1 and 2).

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[2] According to the OECD the difference in life expectancy at birth between Norway and Denmark (in 2009), was 2.1 years for females and 1,8 years for females. At 40 the difference was 2,2 years for females and 2,1 for males. At 65, the difference was 1,6 for females and 1,2 for males (OECD. 2013. OECD Health Data.

Figure 1: Average hospital spending in 2009 for those who died during the year (Males and females, Norway and Denmark)

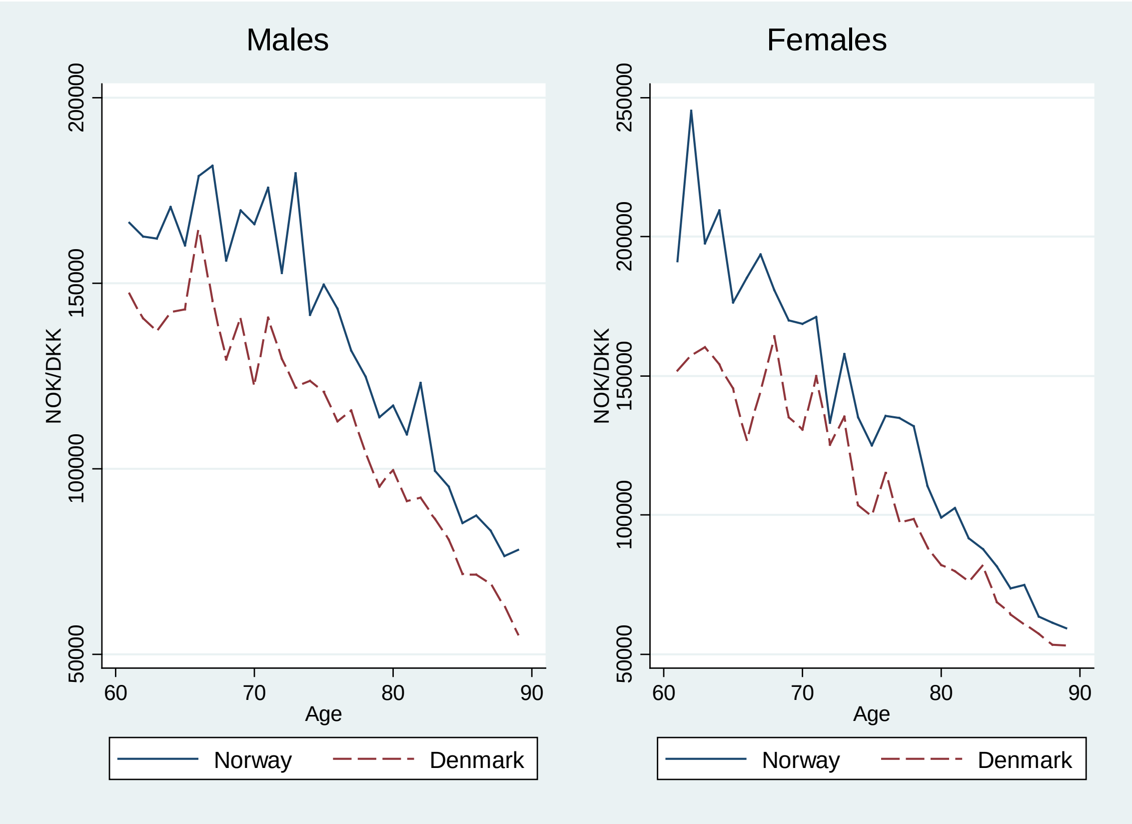
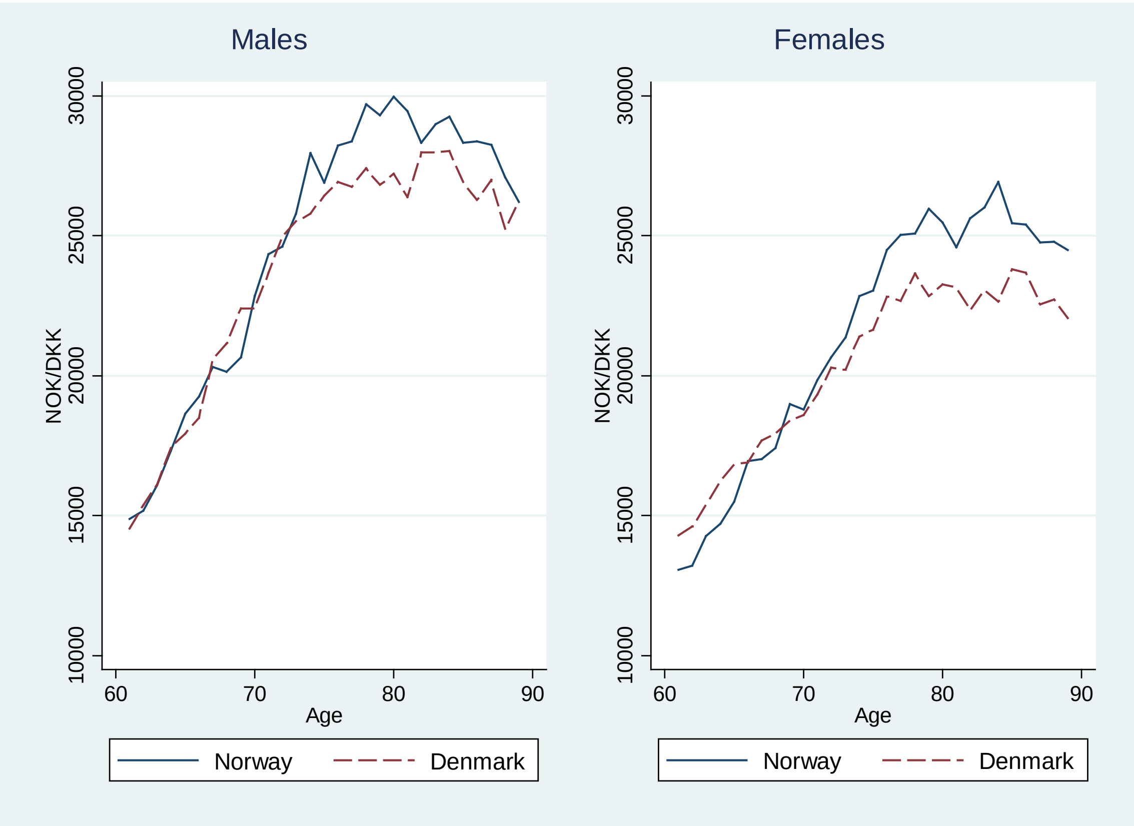


Figure 2: Average hospital spending in 2009 on those who were alive during the whole 2009 (Males and females, Norway and Denmark)



In order to examine whether the three year longer life expectancy makes Norwegian spending on seventy year olds more like Danish sixty-seven year olds, one could try to sum the absolute differences between the curves when comparing Danish and Norwegian seventy year olds and see whether this difference becomes smaller when Norwegian seventy year olds are compared to Danish 67, 68 or 69 year olds. However, this method suffers from several serious problems. First of all spending curves can shift because of income differences as well as differences in health related to life expectancy. Although the two countries have similar cultural and institutional structures, Norway has a significantly higher per capita than Denmark (OECD 2013). Second, even if the two countries were similar, there may still be some differences in terms of accounting standards and what is counted as a hospital cost.

Third, general trends may well be hidden behind cohort similarities. For instance, the generations born during or after World War II, or the generations who experienced polio infections, may vary across countries in a way that dominates the data, make spending on individuals from the same generation look similar across countries, and obscure possible smaller trends across age-groups that are caused by the difference in life expectancy. For these reasons it is not useful to compare the differences in the cost curves directly.

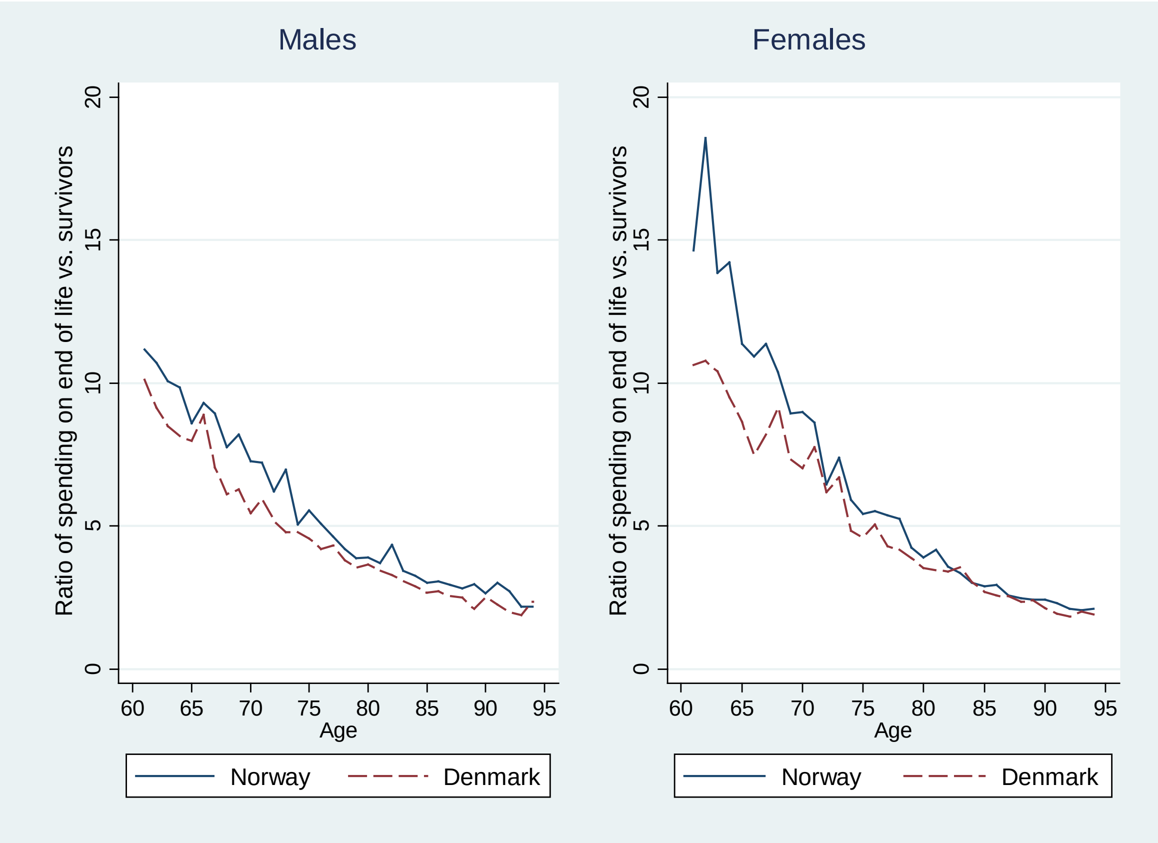
An indicator that is less vulnerable to the objections related to direct comparison of cost curves, is the ratio of health expenditures for individuals who die to those who survive in different age groups. This reduces the problems caused by differences in income, accounting standards and generational similarities because the factors affect both the nominator and denominator in the same direction. Higher income should lead to higher health spending for both groups, regardless of whether they survive the whole year or not. Similarly for differences in accounting standards. For instance including more pharmaceutical expenditures as hospital expenses in one country than the other, will have less effect on the ratio than the overall cost difference.

In addition to the reduced vulnerability to confounding effects, the dead/alive health spending ratio has an interesting property which makes it well suited to identify the effects of increasing life expectancy. If the healthy ageing or shifting hypothesis is correct future seventy year olds will be healthier than current seventy year olds. This will have two consequences. First, health spending on survivors will decrease for a given age. Second, being healthier they will also be able to receive more aggressive treatment compared to current seventy year olds. Some will still die, but those who do will have received more aggressive treatment and for this reason the average cost of dying for those (fewer) who die at seventy will increase. The opposing directions of the two predictions associated with the healthy ageing hypothesis makes the ratio well suited as a target for detecting and isolating the effect of changes in life-expectancy. The nominator, the average cost of those who die, is expected to increase and the denominator, average cost of those who survive, is expected to decrease. Since the hypothesis predicts changes in opposite directions for the nominator and denominator, one would expect the ratio of end of life to survivor spending for given age groups to change significantly if the hypothesis is true. In this sense focusing on the ratio of end of life spending to survivor spending in the different age groups eliminates noise by reducing the effect of confounding factors, and the change in the ratio is well suited to pick up the effect since the hypothesis has opposing implications for the nominator and denominator of the ratio.

3.2 Results

Figure 3 shows the ratios of average cost of those who died to those who survived for males and females in Norway and Denmark in 2009 for different age groups. As predicted by the shifting curve hypothesis, the country with the highest life expectancy (Norway) also has the highest dead/alive spending ratio for the various age groups. There are some stochastic and generational variations, as demonstrated by the fluctuations between the age groups, but the overall trend is clear: The country with the highest life expectancy generally has the highest dead to living spending ratio for most age groups.

Figure 3: Ratio of end of life spending to survivor spending in different age-categories in Norway and Denmark (Males and Females)*



To determine the association between differences in life expectancy and shifts in the cost curve, we calculated the absolute difference (δ) between the ratio curves under different assumptions about the number of years (k) by which the cost curve is shifted:

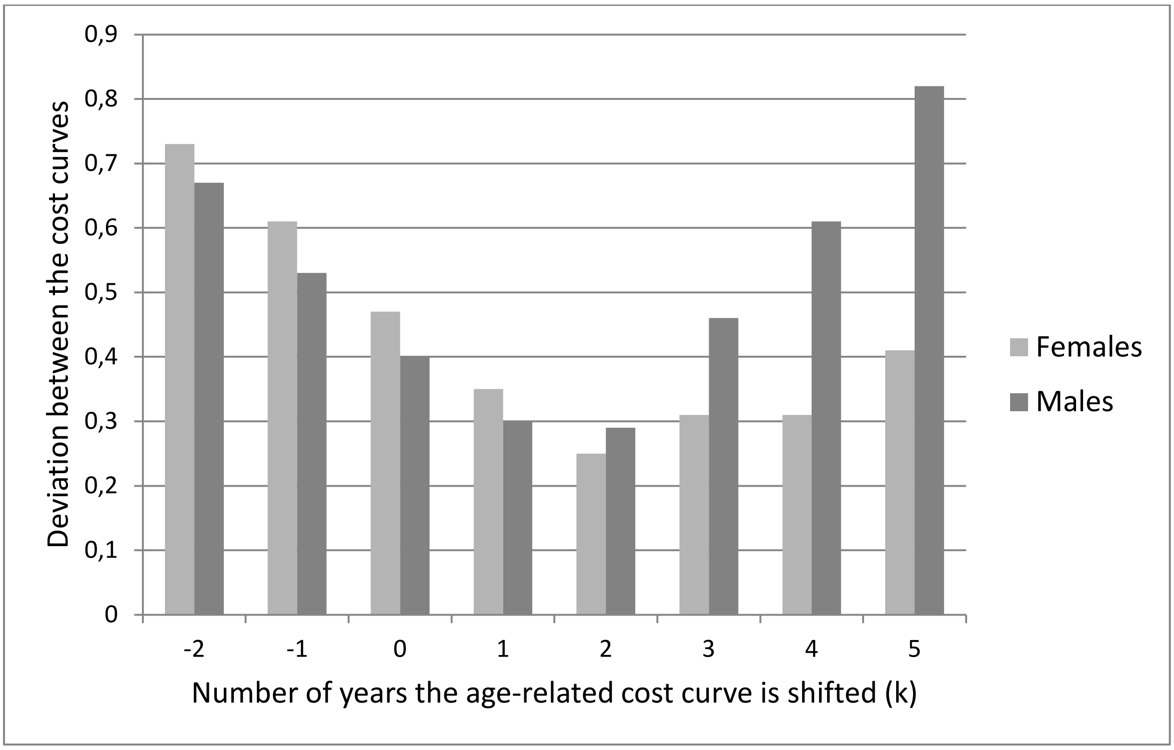
$$\delta(k) = \sum_{a=73}^{a=95} \left| \frac{\bar{c}_a^{D,Den}}{\bar{c}_a^{S,Den}} - \frac{\bar{c}_{a-k}^{D,Nor}}{\bar{c}_{a-k}^{S,Nor}} \right|$$

Given that the difference in life expectancy is three years, the one-to-one proportional shifting hypothesis would predict the best fit when the cost ratio curve is shifted by three years (k = 3, i.e. comparing seventy year olds in the country with the highest life expectancy to sixty-seven year olds in the country with the shortest life expectancy).

Figure 4 shows the average mean deviations from these shifts, from shifting the curve two years in the wrong direction (k=-2), no shift (k=0), and five years in the direction one would expect based on theory (k=5).[3] The results show that for both males and females, the best fit was achieved with a shift of two years. This was smaller than the difference in life expectancy (three years), and it suggests that the optimal shift for cost prediction is less than the change in live expectancy.

[3] The average difference between the curves was calculated for the age-groups between 73 and 95 to avoid comparing age groups in which a large share was retired with people who were not retired. Since most people in both countries are retired at age 68 (the official retirement age is 66 and 67, and the largest examined shift was 5 years, this implied that the starting age had to be 73. The top age limit was set to avoid including age groups in which the end of life costs were unreliable because there were very few people in the groups. There were fewer than 50 deaths in the age groups above 95 years old.

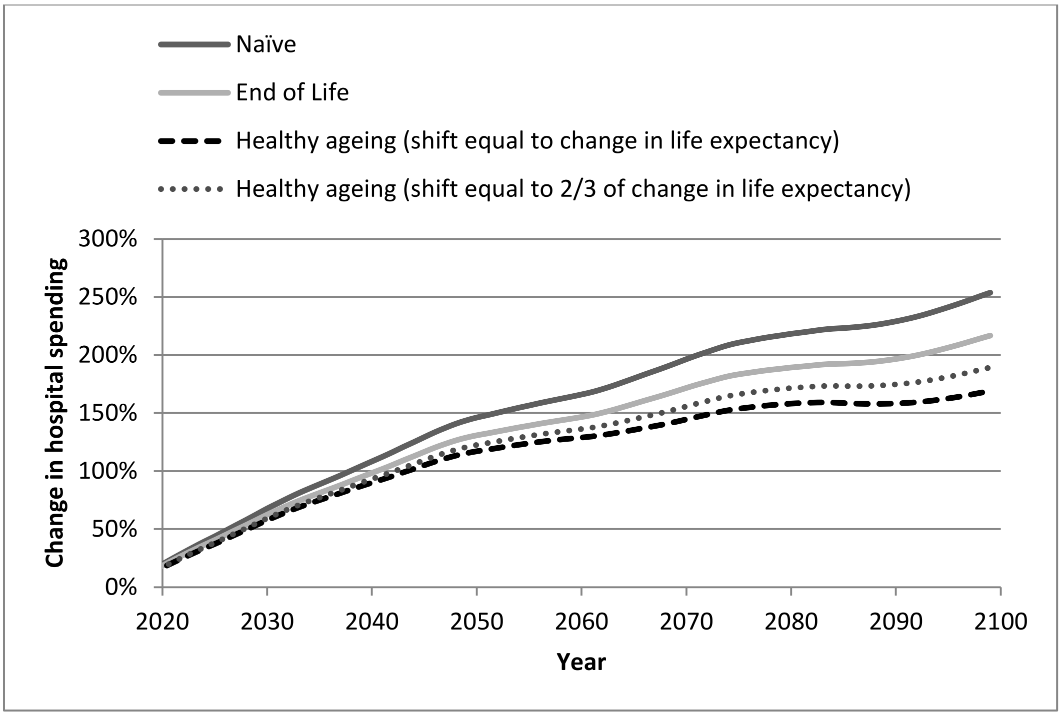
Figure 4: Average deviations between the cost-curves for different values of the healthy ageing parameter (k, number of years the healthy ageing shift the cost curve)



3.3 Implications and limitations

To what extent do the different assumptions about method and costs affect projections of increases in health spending related to demography and ageing? Based on projections of population size, deaths in different age groups and increases in life expectancy obtained from Statistics Norway, Figure 5 illustrates how the methods and assumptions produce different predictions about future spending. The largest difference is between the naïve method and the method based on healthy ageing in which the cost curves are assumed to shift in proportion to changes in life expectancy. In this case the naïve approach projects an increase in the total hospital cost among the old of 254% from 2010 to 2100 while the healthy ageing method projects an increase of 169%. Replacing the assumption of equal changes in cost curves and life-expectancy in the healthy ageing scenario with the assumption that the cost curves only shift two thirds of the changes in life-expectancy, creatres a smaller, but still substantial difference of 20% percentage points.

Figure 5: Projected hospital expenditure using the different methods



The results from comparing Norway and Denmark is important as a first step in order to quantify the shift in the age-related cost curves as life expectancy increases, but there are also some limitations. As larger sets of individual level data from national patient registries become available from more countries, similar studies can be done to examine whether the pattern found in these two countries also hold when comparing other countries and at other times. Another potential weakness is that improvments in health in old age is endogenously caused by higher health spending. The current study has not tried to explore or quantifiy this, but instead focused on how exogogeneous changes in health would shift the spending curves. Exogenous changes are important in themselves since health and life-expectancy historically has been affected by many factors other than health-spending, but a more comprehensive study could try to explore the endogeous and exogenous effects together. Another potentially problematic factor is confounding variables. By focusing on the ratio of spending and comparing two countries at the same point in time the problem of confounding factors is reduced, but not necessarily eliminated. For instance, even if changes in potentially confounding variables like technology and income affect spending on survivors and end of life patients in the same direction, they may do so to different degrees.[4] This is an inherent limitation in a method focusing on a comparison of ratios: The influence of common factors are reduced, but not necessarily eliminated if the common factors affect the nominator and denominator differently.

4 Conclusion

Increasing life expectancy will affects health costs, but multiplying current costs by the expected number of individuals in different age and gender categories overestimates the contribution of age. Separating end of life costs and multiplying by the expected number of deaths and survivors in different age groups avoid this problem, but most likely underestimates the contribution of increasing life expectancy to costs because it assumes that end of life costs will go down when people live longer. The third method of projecting changes in cost solves this by shifting the spending curves, but it raises the question of to what extent healthy ageing shift the age-realted cost curves. It has been suggested that the age-related cost curves should shift in proportion to life expectancy in which case a two year

[4] According to some theories of demand for health, income may shift the demand for health for both survivors and those potentiaolly closer to death. For instance the Grossman model would predict an increased optimal level of health investment as income grows. Other authors, like Zweifel, emphasize that demand for health is stochastically caused by events that induce bad health as age increases. To the extent health spending is government by this, as opposed to Grossman's preventive investment motive, income difference may cause disproportional shifts in spending among those who die as opposed to survivors.

increase in life expectancy should be associated with future seventy year olds having survivor and end of life costs like todays’ sixty-eight year olds. By comparing the spending patterns for end of life and survivors in Norway and Denmark, and using methods to reduce the influence of other variables, the hypothesis of shifting cost-curves was supported, and the shift in the cost curve was similar to the change in life expectancy.

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