The association between age and mortality related hospital expenditures

Evidence from a complete national registry

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Abstract: The aim of this paper is to contribute to the debate on population aging and growth in health expenditures, by providing estimates on how mortality related expenditures are influenced by age. Using a register of inpatient hospital admissions to create gender-cohort specific panels for each of the 430 Norwegian municipalities, we are able to identify mortality related hospital expenditures by separating the impact of mortality on current hospital expenditures from the impact of patients' age and gender. We apply model estimates to quantify the mortality-related hospital expenditures for twenty age groups. Our results, which rely on the assumption that mortalities are exogenous in the empirical specification, suggest that mortality-related hospital expenditures are a decreasing function of age. Furthermore, the results imply that, both age and mortalities should be included when predicting future health care expenditures. The estimation results suggest that 9.0 % of all hospital expenditures are associated with treating individuals in their last year of life. Our results also suggest that the reduction in mortality rates in the period from 1998 to 2009 have, cet. par. contributed to an estimated reduction in total hospital expenditures of 0.6 billion NOK, a difference corresponding to 2 % of the expenditures in 2009.

JEL codes: I11, I12, I19, H51

Key words: mortality related expenditures, hospital expenditures, red herring hypothesis, ageing

1 Introduction and background

In early applications, a population's health care expenditures were commonly modeled as a function of basic demographic characteristics, such as age and gender. This approach applies the well-known fact that different age and gender groups have different health care needs. Using estimates of each group's per capita expenditures, so-called naïve predictions of the population's future health care expenditures can be computed based on future demographic characteristics.

This naïve approach was challenged by researchers who suggested that the expenditures are related to mortalities. In the seminal article by Zweifel et al. (1999) the

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authors hypothesized that time to death is more important than age in predicting future health care expenditure, and this hypothesis is frequently referred to as the *Red Herring Hypothesis*. Applying data on health care expenditures for inhabitants above 65 years of age in Switzerland, they found evidence supporting the *Red Herring Hypothesis*.

More than 30 papers (see among others Salas and Raftery (2001), Zweifel et al. (2001) and Felder et al. (2010)) have been published in the *Red Herring* debate and there appears to be strong evidence suggesting that both age and time to death are factors influencing health expenditures, even though the relative importance of age and time to death is strongly debated. In Colombier and Weber (2011) it is stated that "time to death is of marginal importance", while other studies, Werblow et al. (2007) and Zweifel et al. (2004), claim the opposite; age is of marginal importance. An aspect that has received less attention in the literature is that the costs that are incurred as a result of proximity to death may depend on the age of the individual. In a study of hospital expenditures for elderly decedents in the United States, Levinsky et al. (2001) found that expenditures decreased in age for elderly decedents, and similar findings were also reported by Häkkinen et al. (2008) and Melberg et al. (2013). If expenditures associated with the last year of life are substantially influenced by age, this implies that increasing longevity and postponing death until a higher and less costly age, will contribute to slower growth in health expenditures.[1] The aim of this paper is twofold. Firstly, we aim to quantify the impact of age on mortality related expenditures. Secondly, we aim to assess the influence of changing longevity on hospital expenditures that occur as death is postponed to higher ages where mortality related expenditures are lower.

By estimating the relationship between mortality related expenditures and age, we also contribute to the *Red Herring* debate. If there are large variations in the mortality related expenditures by age, including only time to death and not the interaction between age and mortalities, will yield upwardly biased results when predicting future health care expenditures.

There are several studies (see among others Häkkinen et al. (2008), Emanuel (1996) and Lubitz and Riley (1993)) that present the relationship between age and mortality related expenditures, but the studies only include the elderly part of the population. This paper includes all ages. This is important as the mortality related expenditures among younger individuals also contribute to the total health care expenditures.

Here, we apply data from the Norwegian Patient Registry (NPR) merged with demographic data from Statistics Norway (SSB). An advantage of this study, compared to previous studies is that there is no self-selection into our data. This makes the study unique. The data set follows Norway's population (5 million inhabitants) over a 12 year period from 1998-2009, and we are thus able to assess how the change in longevity over the 12-year period has influenced the expenditures.

The paper proceeds as follows: The study setting is described in the next section (Section 2). In Section 3 we describe the data. Our empirical specification and estimation results are presented in Section 4. Finally, in Section 5 we conclude and discuss the findings.

[1] In addition, length of life increases may, as suggested by Madsen (2004) and Breyer and Felder (2006), influence the morbidity patterns for different ages. It is beyond the scope of this paper to investigate this any further.

2 Study setting

The current organization of the health care system in Norway has many similarities to those in other Nordic countries and the United Kingdom (UK); hospital services are mainly provided by public health institutions, which are financed through general taxation. In Norway, hospitals are governed from the central government by the Ministry of Health, while the general practitioners (GP) and dentists practice privately and contract with the local level of government (municipality and county). At present, the hospital sector in Norway is divided into four Regional Health Enterprises (RHEs) which correspond to geographical areas. Each region receives funding based on per capita funding (60%) and activity based financing (ABF) (40%). ABF is based on the diagnosis related groups (DRG) system (Kalseth et al., 2010). ABF was introduced in June 1997. Note also that the share paid by per capita funding has varied from 1997 until today (Carlsen, 2008).

There is no out of pocket payment for public in-patient hospital services in Norway.[2] The GPs act as gatekeepers for hospitals with an exception of emergency cases, where the ambulance staff or other medical personnel may assign patients directly to the hospital (Johnsen and Bankauskaite, 2006). Patients may choose which hospital he/she would like to be treated at for elective care.

3 Data

3.1 Structure of the data

Two data sources are used in this study: Cost information for hospital admissions are extracted from the NPR and demographic data from SSB. The data from NPR provide a registry of all in-patient hospital admissions in Norway from January 1998 to December 2009. Registration in NPR is compulsory for all hospitals and each admission to the hospital is registered as one observation. It is not possible to track individuals across different hospitals, or different years. A total of 14.5 million admissions were recorded in the given time period, and the included patients are residents of all 430 different municipalities in Norway.

We apply five variables from the database; year of birth, gender, year of hospital stay and the number of DRG-points. Since we cannot identify individuals, we cannot link individual mortalities to hospital stays. We therefore aggregate the data to the smallest possible group where observed mortalities can be linked to observed hospital expenditures, and that is to groups formed by age-gender-specific groups in each Norwegian municipality. From SSB we received, for each year, data on the number of individuals belonging to each of these groups as well as the number of mortalities. Aggregation was performed by grouping the data, and each group was uniquely characterized by a realization of the set of categorical variables age (A_i), gender (G_i), year (T_i) and municipality catchment area (R_i). The variable A_i takes 101 discrete values in the range [0,100], the variable G_i takes two possible values, male or female. Since we have observations from 1998 to 2009 T_i takes 12 unique values. There are 430 municipalities, and hence, R takes 430 unique values. In total there are 101*2*12*430=1,042,320 unique groups formed by different combinations of A_i, G_i, T_i, R_i.

We index the groups by g and we let N_g denote the number of individuals belonging to group g. By computing the total cost of hospital services within the group

[2] There are a few exceptions, and on rare occasions individuals pay out of pocket for in-patient hospital care that is not covered by national insurance. Such payments amount to less than 0.4 % of total expenditures for secondary care (Samdata, The Norwegian Directorate of Health, 2012).

and dividing by the number of persons in each group, we get a per capita measure of hospital expenditures for each group. If we denote the expenditures associated with individual hospital admissions by Y_i , an expression for the per capita expenditures in group g, denoted by $\bar{Y}_g$ is given by:

$$\bar{Y}_g \equiv \frac{1}{N_g} \sum_{i \in g} Y_i$$

3.2 Descriptive statistics

We now provide an overview of the data. Throughout the rest of this paper we measure the expenditures in Norwegian Kroner (NOK) inflation adjusted to 2010 NOK.[3,4] In Table 1 we present the development of demographic characteristics in the period. We observe that although both the general population and the number of elderly older than 64 has increased during this period, the total number of mortalities has been reduced. We also see that the share of the population above 64 years of age has stayed stable at around 16 %.

Table 1: Demographic characteristics

Year	Number of inhabitants age >64	Total mortalities	Number of inhabitants	Share age >64
1998	718463	44119	4436605	16.2 %
1999	714455	44956	4465158	16.0 %
2000	709488	43930	4498328	15.8 %
2001	706532	43837	4520531	15.6 %
2002	705181	44268	4543897	15.5 %
2003	704553	42517	4573057	15.4 %
2004	706575	41280	4598770	15.4 %
2005	711357	41250	4628668	15.4 %
2006	716590	41416	4676098	15.3 %
2007	725038	42158	4716808	15.4 %
2008	739870	42139	4797661	15.4 %
2009	757259	41659	4861059	15.6 %
2010	777056	42025	4919639	15.8 %

In Table 2 we describe the characteristics of the group structure in the data. The average group includes 56 individuals. We observe that there is large variation in group size. The smallest group includes only one individual, whereas the largest group includes 6699 individuals. We also characterize the group level per capita expenditures and the group level mortality rate. We observe that the group level per capita expenditures range from zero to more than one million NOK whereas the group level mortality rate ranges from zero to one.

[3] 8 NOK=1 EURO and 6 NOK=1 USD (2010)

[4] The price level in the health care sector has grown faster than for the rest of the economy, therefore consumer price inflation adjustment may not be sufficient to isolate the changes in use of resources over time.

Table 2: Descriptive statistics of group level variables

Variable	Number of observations	Mean	Std. Dev.	Min	Max
Number of individuals in group N_g	995158	56	183	1	6699
Group level per capita expenditures [a] $\bar{Y}_g \equiv \frac{1}{N_g}\sum_{i\in g} Y_i$.	995158	10454.79	17153.82	0	1006657
Group level mortality rate $\bar{D}_g \equiv \frac{1}{N_g}\sum_{i\in g} D_i$.	995158	0.0341476	0.1229989	0	1

[a] The expenditure reported in the table is the expenditure related to activity (patient treatment) and not other costs such as pension costs in the health enterprises. The number is therefore lower than the cost reported in OECD and Norwegian Ministry of Health for inpatients in somatic care.

Furthermore, figure 1 describes per capita hospital expenditures for males and females. The expenditures are high for newborns and people above 60 years of age. The expenditures for women are clearly higher than males in the childbearing years (i.e. between the age of early twenties and late thirties), while males have higher expenditures for the ages above 50.

Figure 1: Hospital expenditures per capita measured in NOK by age, 1998-2009

4 Estimation and results

Our aim is to quantify the mortality related expenditures in a situation where mortalities are only observable at a group level. We aggregate our data to obtain data in a format including observable variables at group level which still enables us to identify the effect of mortalities on hospital expenditures at the individual level. To do this, we let Y_i refer to individual i's total hospital expenditures in a given year. We assume a linear regression function, relating these expenditures to observable characteristics:

$$1)\ Y_i = \gamma_0 + \gamma_1 X_i + \gamma_2 D_i + u_i,\ u_i \sim iid\left(0, \sigma^2\right)$$

where γ_1 and γ_2 are a vectors of unknown parameters to be estimated and γ_0 is an unknown scalar parameter to be estimated. The matrix X_i is a matrix of dummy variables capturing the effect of age and gender, including interaction terms. We distinguish between 20 different age groups in our regression model, infants and children aged 1-4, and we also categorize age in 5 year intervals until age 85-90. Individuals older than 90 are grouped together. The variable D_i is an indicator variable equal to one if the individual i died within the year. This variable is not observable due to the fact that we may not link current or future mortalities with hospital admissions; hence, estimating 1) is not feasible. However, the number of mortalities within each *group* each year, $\sum_{i \in g} D_i$, *is* observable and included in our data. Thus, we may estimate the impact of mortalities in each group on the group level hospital expenditures. If we index groups by g, and let N_g denote the number of observations in group g, we may express a regression equation where only observable variables are included, and where we may identify and estimate the unknown constants from 1): By summing over i on each side of 1) and dividing by N_g, equation 1) can be written based on the group means from each year:

$$2)\ \frac{1}{N_g} \sum_{i \in g} \left[Y_i\right] = \frac{1}{N_g} \sum_{i \in g} \left[\gamma_0 + \gamma_1 X_i + \gamma_2 D_i + u_i\right]$$

Applying the notation $\overline{Y}_g \equiv \frac{1}{N_g} \sum_{i \in g} Y_i$ we may write 2) as

$$3)\ \overline{Y}_g = \gamma_0 + \gamma_1 \overline{X}_g + \gamma_2 \overline{D}_g + \overline{u}_g$$

We note that the error terms in equation 3) are heteroscedastic, due to variation in the size of the groups, N_g.

One may argue that the mortality rate for each age group may be endogenous, and partly influenced by the health expenditures. However, one may argue that the potential simultaneity bias is likely to be small when analyzing Norwegian data, as Norway offers universal health insurance and full coverage for the whole population and the health care spending is high. The life expectancy at birth in Norway in 2011 was 79 years for males and 83.5 for females according to Statistics Norway. This is among the highest in the Organization for Economic Co-operation and Development (OECD), and one may argue that the marginal effect of hospital expenditures in terms of higher group level survival within the given year is likely to be very small for Norwegian patients.

However, we test the assumption that mortalities represent an exogenous variable in equation 3) by means of a Wu-Hausman and a Durbin test: We use the mortality rate in year *t-1*, as an instrument for the mortality rate in year *t*. The mortality rate in year *t-1* is likely to be correlated to the mortality rate in year *t*; however, it is clearly not a function of the health care expenditure in year *t*. We run two stage least squares (2SLS) and test the assumption that mortalities are exogenous. Based on the tests we cannot reject the null hypothesis that mortalities are exogenous (both tests with a p-value=0.9). The tests were performed on 3) with instruments; the 2SLS regression may be found in the appendix (Table A.1).

For the rest of the analysis, we will assume that we may treat mortalities as exogenous. Furthermore, we apply a Wooldridge test for serial correlation in panel data models, and the null hypothesis of no serial correlation is rejected in favor of a regression model with a first order autoregressive process (AR1) in the error terms (p=0.00). The test was performed on 3). The test results indicate that appropriate modeling and estimation should take both serial correlation and heteroscedasticity into account. We estimated 3) taking into account the AR1 process in the error terms, and the results from estimation is presented in Table 3. The resulting standard errors of the estimates were slightly larger compared to the results from a model estimated by means of weighted least squares (WLS) under the assumption of no serial correlation. The results for WLS regression assuming no serial correlation may be found in the appendix (Table A.2).

In Table 3a we observe that all the estimated coefficients for both age and mortalities are significant. The estimated coefficients are also statistically significant when excluding mortalities (Table 3b), a model referred to as *the naïve approach* in Häkkinen et al. (2008).

Based on the regressions presented in Table 3a, we may now describe how mortality related hospital expenditures (MRE), defined as the estimated marginal effect of mortalities on hospital expenditures, depend on age. In Figure 2, we present the relationship between age and MRE. We observe that MRE is highest for the age groups below 60 and declines sharply for the older age groups. We also observe that female decedents have a larger MRE than males until the age of 75, while after the age of 75 male decedents have the largest MRE. This is in accordance with the findings in Melberg et al. (2013).

Furthermore, Figure 3 presents estimated increase in per capita health care expenditures by age excluding the effect of mortalities, based on the regression results presented in Table 3a. The figure shows that the health care expenditures for newborns and elderly are high compared to the rest of the population. Furthermore, the expenditures for females are higher than for males for the ages 15 and 54. Above the age of 54 the expenditures for males are higher for males than for females.

In Tables 4a and 4b we present the estimated hospital expenditures for survivors and decedents separately for males and females. The table is based on the regression results presented in Table 3a combined with demographic information from Statistics Norway.

Table 3a: Results from weighted regression analysis of hospital expenditures assuming serial correlation in error terms

Dependent variable: Per capita expenditures

	Females				Males			
	Age		Mortality rate by age		Age		Mortality rate by age	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
0	23527.2***	(88.36)	119988.2***	(11426.8)	25429.8***	(87.78)	65412.4***	(9828.8)
1-4	1458.2***	(55.61)	215537.1***	(15404.9)	2255.0***	(55.06)	176742.4***	(15258.7)
5-9	171.4***	(50.59)	193107.8***	(23562.0)	585.5***	(51.61)	96843.6***	(17469.4)
10-14	Reference group		111588.5***	(22256.4)	112.9*	(51.61)	129338.8***	(19598.0)
15-19	966.9***	(51.40)	87140.5***	(15862.7)	611.1***	(52.49)	64229.1***	(9845.1)
20-24	2671.1***	(53.31)	60250.2***	(13546.0)	1023.1***	(53.24)	43107.9***	(7481.1)
25-29	4675.9***	(52.23)	68019.8***	(12891.9)	1113.7***	(52.33)	44369.7***	(7766.7)
30-34	5121.4***	(51.13)	80850.6***	(12473.2)	1431.9***	(51.09)	53933.5***	(7922.2)
35-39	4051.6***	(50.94)	103846.1***	(10135.8)	1860.0***	(50.86)	50064.8***	(7338.8)
40-44	3368.7***	(51.68)	118871.9***	(8539.3)	2443.2***	(51.46)	89489.5***	(6177.9)
45-49	3946.7***	(52.60)	132076.5***	(6305.6)	3441.8***	(52.60)	75365.7***	(4960.4)
50-54	5039.8***	(53.55)	140986.2***	(4841.1)	4975.2***	(53.98)	95812.3***	(3984.0)
55-59	6554.6***	(55.64)	138076.1***	(3977.4)	7250.8***	(56.34)	107490.7***	(3092.0)
60-64	8669.5***	(59.28)	121013.7***	(3155.1)	10227.9***	(61.15)	105001.6***	(2366.4)
65-69	11038.7***	(64.33)	109558.5***	(2532.2)	13890.7***	(68.90)	95870.9***	(1853.0)
70-74	13846.3***	(69.05)	99365.6***	(2007.7)	17779.9***	(76.86)	81194.3***	(1448.1)
75-79	17023.1***	(74.85)	61976.1***	(1457.7)	21308.7***	(86.99)	63649.4***	(1097.0)
80-84	18933.6***	(86.07)	39107.5***	(1054.5)	22987.3***	(105.9)	46879.7***	(863.3)
85-89	20119.3***	(108.9)	22423.0***	(793.4)	23969.9***	(140.8)	29566.5***	(713.3)
90+	19039.2***	(128.0)	5935.6***	(433.9)	22770.4***	(197.7)	15246.1***	(525.2)

Constant -363.4*** (41.49)

Year

1998	Reference group	
1999	542.0***	(24.59)
2000	349.6***	(27.28)
2001	945.7***	(27.86)
2002	1413.9***	(27.96)
2003	1869.4***	(27.96)
2004	1844.2***	(27.93)
2005	2184.7***	(27.89)
2006	2489.5***	(27.82)
2007	2733.4***	(27.77)
2008	2463.6***	(27.66)
2009	2744.9***	(27.68)

Note: * for $p<0.05$, ** for $p<0.01$, and *** for $p<0.001$. Number of observations: 991 930.

Table 3b: Results from weighted regression analysis of hospital expenditures assuming serial correlation in error terms – without controlling for mortality

Dependent variable: Per capita expenditures

	Females		Males	
	Coefficient	Standard error	Coefficient	Standard error
0	23796.5***	(84.27)	25596.7***	(82.60)
1-4	1503.5***	(56.64)	2297.7***	(56.02)
5-9	179.8***	(51.56)	586.0***	(52.70)
10-14	Reference group		116.8*	(52.70)
15-19	976.2***	(52.31)	629.9***	(53.39)
20-24	2673.8***	(54.29)	1045.8***	(53.90)
25-29	4679.2***	(53.15)	1140.0***	(52.87)
30-34	5133.9***	(51.95)	1468.0***	(51.56)
35-39	4103.1***	(51.66)	1906.7***	(51.15)
40-44	3475.1***	(52.12)	2575.8***	(51.58)
45-49	4148.6***	(52.75)	3619.0***	(52.26)
50-54	5399.6***	(53.14)	5351.6***	(52.65)
55-59	7103.2***	(54.42)	7925.2***	(54.01)
60-64	9425.0***	(57.06)	11330.6***	(57.11)
65-69	12111.3***	(60.66)	15590.3***	(61.89)
70-74	15465.2***	(62.10)	20182.8***	(65.18)
75-79	18854.4***	(62.43)	24524.3***	(68.36)
80-84	21043.6***	(65.33)	26977.9***	(77.06)
85-89	22333.2***	(75.23)	28074.7***	(100.3)
90+	20166.3***	(96.77)	26409.1***	(154.9)

Constant -290.1*** (42.33)

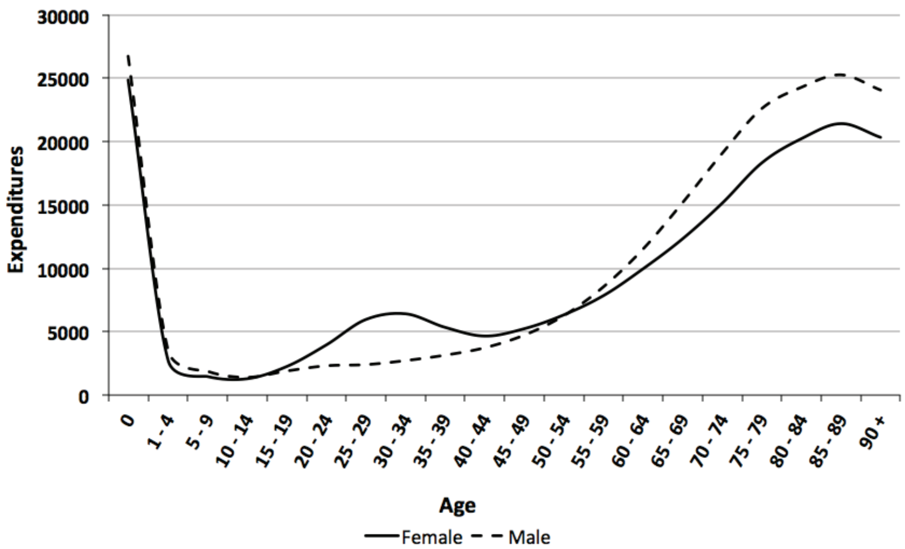
Year

1998	Reference group	
1999	545.1***	(24.90)
2000	335.5***	(27.72)
2001	923.0***	(28.34)
2002	1388.9***	(28.47)
2003	1819.3***	(28.46)
2004	1775.5***	(28.43)
2005	2104.8***	(28.39)
2006	2397.9***	(28.33)
2007	2640.3***	(28.27)
2008	2361.0***	(28.16)
2009	2628.1***	(28.18)

Note: * for p<0.05, ** for p<0.01, and *** for p<0.001.
Number of observations: 991 930.

Figure 2: Estimated increase in per capita hospital expenditures associated with the last year of life at different ages

Figure 3: Estimated per capita hospital expenditures by age excluding the effect of mortalities



As expected, the decedents have a higher per capita expenditure than survivors for all age groups. The number of decedents is small compared to the number of survivors, and the total expenditures are therefore higher for survivors than decedents. This holds for all age groups. In Tables 4a and b we see that even though the estimated MRE is falling with age, the total share of the hospital expenditures used by decedents increases with age. This is caused by the higher number of decedents in higher age groups. We also see that 10% of the total hospital expenditures for males are used by male decedents, whereas the corresponding figure for females is 8%. In total, for both genders, hospital expenditures among decedents comprise 9.0% of total hospital expenditures. In the international literature (Scitovsky, 1984; Polder et al., 2006; Hogan et al., 2001; Nord et al., 1989; Emanuel, 1996) the health care expenditures associated with the last year of life are estimated to be somewhere in between 10% and 30% of the total health care expenditures. The different studies include different components of total health expenditures, and/or selected segments of the population; hence, the results from different studies are not directly comparable.

In Tables 4a and b the demographic composition are the average over the period of observations (1998-2009). In the following sections, we will change this composition in order to observe how this may change the expenditure patterns. First, we hold the demographic composition equal to the one observed in 1998 and then 2009. Based on the composition in 1998, the share of total health care expenditures used by decedents is equal 9.8%. Based on the demographic composition in 2009, the corresponding number is 8.1% (see Table 5). The reason for the decline is two-fold. First, increased length of life increases the number of mortalities in higher ages with lower mortality related expenditures. Second, the share of decedents decreases in the time period.

Table 4a: Estimated expenditures in 1000 NOK for males per year

Age	MRE per capita	No. of Decedents	Expenditure per capita excluding MRE	No. of Survivors	Total expenditure for decedents	Total expenditure for survivors	Total*	Share used by decedents
0	65	100	27	29606	9191	791072	800263	1 %
1 - 4	177	41	4	119896	7445	425048	432492	2 %
5 - 9	97	20	2	154720	1943	290200	292143	1 %
10 - 14	129	18	1	155041	2383	217522	219906	1 %
15 - 19	64	76	2	146764	5016	279031	284047	2 %
20 - 24	43	136	2	140607	6185	325262	331447	2 %
25 - 29	44	156	2	151930	7279	365213	372492	2 %
30 - 34	54	172	3	169348	9720	460968	470688	2 %
35 - 39	50	216	3	175738	11505	553592	565097	2 %
40 - 44	89	273	4	169022	25481	631021	656502	4 %
45 - 49	75	397	5	159694	31829	755667	787496	4 %
50 - 54	96	626	6	154606	63855	968651	1032505	6 %
55 - 59	107	887	9	140076	102943	1196386	1299329	8 %
60 - 64	105	1192	12	113146	138882	1303220	1442103	10 %
65 - 69	96	1529	15	85009	169782	1290503	1460285	12 %
70 - 74	81	2171	19	71603	217638	1365470	1583108	14 %
75 - 79	64	3243	23	61155	279690	1382030	1661720	17 %
80 - 84	47	3990	24	42454	283901	1030663	1314565	22 %
85 - 89	30	3397	25	20720	186226	523382	709608	26 %
90 +	15	2235	24	7244	87853	174284	262137	34 %
Total all age groups					1648747	14329185	15977933	10 %

Total expenditures = Total expenditures for survivors + Total expenditures for decedents =[(Constant term weighted by the number of observations each year+ marginal increase in health care expenditures excluding MRE) # survivors] + [Constant term weighted by the number of observations each year + marginal increase in health care expenditure excluding MRE + MRE)* # decedents].

Table 4b: Estimated expenditures in 1000 NOK for females per year

Age	MRE per capita	No. of Decedents	Expenditure per capita excluding MRE	No. of Survivors	Total expenditure for decedents	Total expenditure for survivors	Total*	Share used by decedents
0	120	74	25	28124	10698	697961	708658	2 %
1 - 4	216	32	3	114266	7092	314041	321134	2 %
5 - 9	193	15	1	147036	3012	214900	217912	1 %
10 - 14	112	16	1	146941	1772	189574	191346	1 %
15 - 19	87	34	2	139204	3073	314194	317267	1 %
20 - 24	60	44	4	135637	2801	537286	540088	1 %
25 - 29	68	57	6	148745	4181	887420	891601	0 %
30 - 34	81	72	6	164195	6279	1052742	1059020	1 %
35 - 39	104	106	5	168451	11563	899825	911387	1 %
40 - 44	119	158	5	161787	19546	753742	773288	3 %
45 - 49	132	247	5	153788	33960	805356	839317	4 %
50 - 54	141	393	6	149090	57894	943724	1001618	6 %
55 - 59	138	555	8	136208	80966	1068518	1149484	7 %
60 - 64	121	723	10	113929	94740	1134689	1229429	8 %
65 - 69	110	902	12	91409	109911	1126963	1236874	9 %
70 - 74	99	1398	15	84252	160062	1275279	1435340	11 %
75 - 79	62	2490	18	82019	199913	1502025	1701938	12 %
80 - 84	39	4018	20	69732	238396	1410252	1648648	14 %
85 - 89	22	4987	21	44446	218587	951558	1170145	19 %
90 +	6	5470	20	22153	143658	450348	594007	24 %
Total all age groups					1408104	16530397	17938501	8 %

Total expenditures = Total expenditures for survivors + Total expenditures for decedents =[(Constant term weighted by the number of observations each year+ marginal increase in health care expenditures excluding MRE) # survivors] + [Constant term weighted by the number of observations each year + marginal increase in health care expenditure excluding MRE + MRE)* # decedents].

In order to further investigate the influence of changes in demographic composition on health care expenditures we hold the number of inhabitants equal to that in 2009, but hold the mortality rates equal to 1998. By this approach the share used by decedents increase to 10.0 % in 2009 (see Table 5). The reason for the increase is increased mortality rates for almost all age groups apart from the 90+ age group. Hence, an increased length of life reduces the mortality related hospital expenditures. Furthermore, the increased length of life leads to a reduction in the total expenditures with 2% (0.6 billion NOK) (see Table 5).

In summary, our results supports the claim that mortalities are, *ceteris paribus*, associated with higher hospital expenditures. We show that when life expectancy increases the naïve models will produce biased projections of future hospital expenditures. The results also show that even though the decedents incur high expenditures on hospital services, the decedent's expenditures comprise a relatively small share of the total hospital expenditures (9 %).

Table 5: The effect of increasing longevity on total hospital expenditures in Norway

- Assuming the same per capita expenditures as in the regression presented in Table 3, but changed demographic composition[5]

	Demographic composition as in 2009				**Demographic composition as in 1998**				**Demographic composition as in 2009, but mortality rates as in 1998**			
	Male		**Female**		**Males**		**Female**		**Males**		**Female**	
Age	# D	# S	# D	# S	# D	# S	# D	# S	# D	# S	# D	# S
0	96	31737	58	29916	129	29497	85	28192	139	31694	90	29884
1-4	33	122577	30	116642	49	123554	43	116730	49	122561	43	116629
5-9	17	151276	13	145132	22	155843	11	147574	21	151272	11	145134
10-14	14	160836	13	152417	21	138363	19	131782	24	160826	22	152408
15 - 19	73	163948	37	155177	70	133768	35	127232	86	163935	43	155171
20 - 24	105	153315	46	146643	164	141842	44	137927	177	153243	47	146642
25 - 29	145	151494	52	146855	177	169082	58	164089	159	151480	52	146855
30 - 34	139	159013	59	153778	202	175598	92	166903	183	158969	85	153752
35 - 39	185	181973	98	173849	250	163026	114	155779	279	181879	127	173820
40 - 44	274	186904	133	176770	325	158962	183	153781	382	186796	210	176693
45 - 49	341	171124	230	162081	436	152679	253	145844	488	170977	281	162030
50 - 54	576	161823	398	155927	729	154386	474	147707	763	161636	500	155825
55 - 59	869	149491	494	145311	783	107923	462	107431	1083	149277	624	145181
60 - 64	1370	146777	843	144273	1163	85527	592	89905	1987	146160	949	144167
65 - 69	1576	104472	976	107548	1701	81305	924	89531	2173	103875	1109	107415
70 - 74	1846	73750	1250	83800	2788	75778	1676	92348	2683	72913	1516	83534
75 - 79	2608	58670	1916	74087	4019	64204	3116	91629	3610	57668	2500	73503
80 - 84	3524	43704	3469	65401	4079	38114	4246	67322	4566	42662	4086	64784
85 - 89	3695	25000	5220	50212	3081	17652	4793	39129	4264	24431	6049	49383
90 +	2609	8907	6238	26781	1446	5906	4262	18078	2265	9251	6299	26720
Expenditures	Share of total health care expenditures used on decedents 8.1%				Share of total health care expenditures used on decedents 9.8%				Share of total health care expenditures used on decedents 10.0%			
	Total expenditures in billion NOK 35.8				Total expenditures in billion NOK 32.8				Total expenditures in billion NOK 36.4			

5 Policy implications and conclusion

In our analysis we find that 9% of all hospital expenditures from 1998 to 2009 were spent on individuals in their last calendar year of life. Our analysis also suggests that mortality related expenditures are a decreasing function of age.

Our analysis supports the inclusion of both mortalities and age in predictions of future hospital expenditures. We provide an estimate of how increasing longevity over a twelve year period has influenced total hospital expenditures in Norway, and find that it had an impact of 2 percentage points in the period 1998-2009. Thus we conclude that the naïve approach is insufficient to predict future health care expenditures.

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[5] #D : Number of decedents , #S : Number of survivors

The *Red Herring Hypothesis* as it was formulated by Zweifel et al. (1999) states that; 1) time to death do influence health care expenditures, 2) age do not influence health care expenditures. We use the mortality rate in the last calendar year of life, and not time to death. Hence, our assumptions and empirical specification is not tailored to test the Red Herring Hypothesis. Given the assumption that our regression equation is correctly specified, we clearly reject the hypothesis that hospital expenditures is unaffected by age.

The main implication of our results is that increasing longevity may bring about reductions in mortality related expenditures as death is postponed until higher ages, and these reductions in mortality related health expenditures should be taken into account when predicting future health expenditures. Furthermore, as mortality related expenditures are dependent on age, our study suggest that only including time to death without the interaction with age, will give misleading results when predicting future health care expenditures.

Finally, it is important to emphasize that several other factors such as technological progress and general growth in gross domestic product influence the health care spending, and not demographic factors alone (Häkkinen et al., 2008).

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