Hospital expenditures and the red herring hypothesis: Evidence from a complete national registry

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Key words: Red Herring Hypothesis, hospital expenditures, mortality related expenditures

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Abstract

The aim of this paper is to contribute to the debate on population aging and growth in health expenditures. The Red Herring hypothesis, i.e., that hospital expenditures are driven by the occurrence of mortal illnesses, and not patients' age, forms the basis of the study. The data applied in the analysis are from a complete registry of in-patient hospital expenditures in Norway from the years 1998-2009. Since data registration is compulsory and all hospital admissions are recorded, there is no self-selection into the data. Mortality related hospital expenditures were identified by creating gender-cohort specific panels for each of the 430 Norwegian municipalities. We separated the impact of mortality on current hospital expenditures from the impact of patients' age and gender. This approach contributes to the literature by applying sensible aggregation methods on a complete registry of inpatient hospital admissions.

We apply model estimates to quantify the mortality related hospital expenditures for twenty age groups. The results show that mortality related hospital expenditures are a decreasing function of age. Further the results clearly support that, both age and mortalities should be included when predicting future health care expenditure. The estimation results suggest that 9.2 % of all hospital expenditure is associated with treating individuals in their last year of life.

Introduction and background

A population's health care expenditures are 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. Upon knowing each age/gender group's expected expenditures, so called naïve estimates of the populations future health care expenditures can be computed based on future demographic characteristics.

This naïve approach was challenged by researchers who suggested that the expected number of decedents should be included as a separate factor. Some researchers went further and suggested that time to death could be more important than age in predicting future health care expenditure. In the debate that followed (Zweifel, Felder, & Meiers, 1999)'s seminal article, the hypothesis that time to death is more important than age in predicting health care expenditure is referred to as the *Red Herring hypothesis*. (Zweifel et al., 1999) studied the health care expenditures for inhabitants above 65 years of age in Switzerland. They found that time to death is more important than age in predicting future health care expenditure. The study has however, been criticized for methodological problems. The two main problems which have been addressed are, endogeneity of time to death in models of health expenditures, and multicollinearity between the explanatory variables (age and time to death) (Häkkinen, Martikainen, Noro, NIHTILA, & Peltola, 2008; Salas & Raftery, 2001). More than 30 papers 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 & Weber, 2011) it is stated that "time to death is of marginal importance", while other studies (Werblow, Felder, & Zweifel, 2007; Zweifel, Felder, & Werblow, 2004) claim the opposite; age is of marginal importance.

The aim of this paper is; first, estimate the share of hospital expenditures used by decedents and survivors, second, test if the naïve (age only) method may be used for certain or all age groups.

We apply data from the Norwegian Patient Registry (NPR) merged with demographic data from Statistics Norway (SSB). The advantage of the study compared to previous studies discussed above is that Norway has a complete register, and hence, there is no self selection in the data, this makes this study unique. The data set follows Norway's population (5 million inhabitants) over a 12 year period. In comparison the sample size in (Zweifel et al., 1999) is 8000 and (Häkkinen et al., 2008) 300 000. The large data set in our analysis will marginalize the problem of multicollinearity between the explanatory variables (age and death rate), previously discussed in the literature.

The current organizing of the health care system in Norway has many similarities to the other Nordic countries and the United Kingdom (UK); hospital services are mainly provided by public health institutions and these 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 are privately practicing and contract with a local level of government (municipality and county). Presently 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, Magnussen, Anthun, & Petersen, 2010). ABF was introduced in June 1997. Note also that the share paid by a per capita funding has changed from 1997 until today (Carlsen, 2008).

There is no out of pocket payment for in-patient hospital services in Norway. The GPs work 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 & Bankauskaite, 2006). Patients may choose which hospital he/she would like to be treated at for elective care.

The paper proceeds as follows: First, we describe the data. Second, our empirical specification and results are described. Finally, we conclude and discuss the findings.

Data

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 complete registry of all hospital admissions in Norway from January 1998 to December 2009, and contains data on somatic in-patient care and rehabilitation. Registration in NPR is compulsory for all hospitals; hence, there is no self-selection into the dataset. Each admission to the hospital (hospital stay) is registered as one observation, and it is not possible to track individuals between admissions at different hospitals. A total of 14.5 million admissions are recorded in the given time period, and the included patients are residents of all 430 different municipalities in Norway.

Our data from NPR contain five variables for each admission; year of birth, gender, year of hospital stay and DRG-points. Since we can not track individuals between admissions, and further, since we can not link individual mortalities to hospital stays, we 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 within each group 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 took 101 discrete values in the range [0,100], the variable G_i took two possible values, male or female. Since we had observations from 1998 to 2009 we had observations of 12 different years, therefore T_i takes 12 unique values. There were 430 municipality areas, and hence, R takes 430 unique values. Therefore, there were 101*2*12*430=1,042,320 unique groups formed by different combinations of A_i, G_i, T_i, R_i .

We indexed 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 and dividing by the number of persons in each group, we get a per capita measure of hospital expenditures. 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 $\overline{Y}_g$ is given by:

$$\overline{Y}_g = \frac{1}{N_g} \sum_{i \in g} Y_i$$

Descriptive statistics

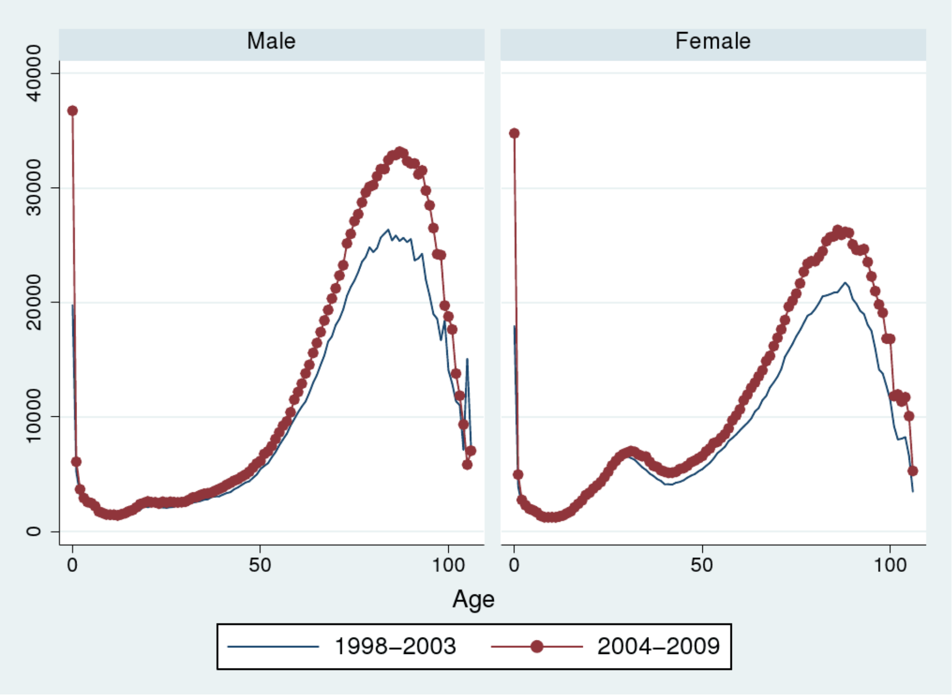
This section will give a short overview of the data. For the whole analysis (the rest of this paper) the expenditure will be measured in Norwegian Kroner (NOK) inflation adjusted to 2010 NOK. We describe total and per capita hospital expenditures. We also see that the share of the population above 64 years of age is stable 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 figure 1 we describe per capita hospital expenditures for males and females in two separate periods. In order to see how the expenditures have developed, we compared the per capita expenditures for the first six years with the last six years in the data set.

Figure 1: Hospital expenditures per capita measured in NOK by age



As shown in figure 1, the expenditure is high for newborns and people above 60 years of age. Further the expenditures for women are clearly higher than males in the childbearing years (i.e. between the age of early twenties and late thirties). We observe a decline in expenditures for individuals in the age groups above 95. When comparing the years 1998-2003 with 2005-2009, the increase in hospital expenditure is observed mainly for the newborns and individuals above 60 years of age.

Empirical specification and estimation

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) $Y_i = \gamma_0 + \gamma_1 X_i + \gamma_2 D_i + u_i$, $\mathrm{u_{igt}} \sim \mathrm{iid}\left(0, \sigma^2\right)$

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 19 different age groups in our regression model, infants aged zero, children aged 1-4, and further we 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, and hence, estimating 1) is not feasible. However, the number of mortalities within each *cell* 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 cell on the cell level hospital expenditures. If we index cells 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 on each side of 1) and dividing by N_g, equation 1) can be written based on cell 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 cells, N_g.

Table 2: Cell descriptive statistics

Variable	Number of observations	Mean	Std. Dev.	Min	Max
Cells (group; g) by year	995158	82929	-	82436	83716
Number of individuals by group N_g	995158	55.58475	183.2026	1	6699
[a]Per capita expenditures by group $\overline{Y}_g \equiv \frac{1}{N_g}\sum_{i\in g} Y_i$	995158	10454.79	17153.82	0	1006657
Death rate by group $\overline{D}_g \equiv \frac{1}{N_g}\sum_{i\in g} D_i$	995158	.0341476	.1229989	0	1

[a]Note: 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.

As mentioned in the introduction, several papers discuss whether mortality rate for each age group may be endogenous, and partly influenced by the health expenditures. One may argue that potential simultaneity bias can be ignored when analyzing Norwegian data, as health care spending is high with universal health insurance and full coverage for the whole population. The life expectancy at birth in Norway in 2011 was 79 years for males and 83.5 females according to Statistics Norway. This is among the highest in the The Organisation for Economic Co-operation and Development (OECD), and one may argue that marginal gains in terms of life expectancy from increased hospital expenditure for Norwegian patients are likely to be small.

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* is likely to be correlated to the mortality rate in year *t-1*, however, it is clearly not a function of the health care expenditure in year *t*. We run two stage least squares (2SLS) and test for endogeneity. Based on the tests we can not reject the null hypothesis that mortalities are exogenous (both with a p-value=0.9). The test was performed on the unweighted version of 3) with instruments, as application of this test does not allow for weighting the observations. The 2SLS regression may be found in the appendix (table 5).

We will in the rest of the analysis, assume that we may treat mortalities as exogenous. Further 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 the unweighted version of 3), as application of this test does not allow for weighting the observations. Based on the test result, 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. The resulting standard errors of the estimates was slightly larger compared to the results from model 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 6).

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

Dependent variable	**Per capita expenditures**		**Per capita expenditures**	
Independent variable	**Independent variables including mortalities**		**Independent variables excluding mortalities**	
	Coefficient	Standard error	Coefficient	Standard error
Age, females				
0	23355.8***	(88.08)	23616.7***	(83.93)
1-4	1286.8***	(53.76)	1323.7***	(54.66)
5-9	Reference group		Reference group	
10-14	-171.4***	(50.59)	-179.8***	(51.56)
15-19	795.5***	(52.95)	796.5***	(53.96)
20-24	2499.7***	(53.37)	2494.0***	(54.36)
25-29	4504.5***	(52.21)	4499.5***	(53.12)
30-34	4950.0***	(51.10)	4954.1***	(51.91)
35-39	3880.2***	(50.91)	3923.3***	(51.62)
40-44	3197.3***	(51.65)	3295.4***	(52.08)
45-49	3775.3***	(52.57)	3968.9***	(52.72)
50-54	4868.4***	(53.52)	5219.9***	(53.11)
55-59	6383.2***	(55.62)	6923.5***	(54.39)
60-64	8498.1***	(59.26)	9245.2***	(57.03)
65-69	10867.3***	(64.31)	11931.5***	(60.64)
70-74	13674.9***	(69.03)	15285.4***	(62.07)
75-79	16851.7***	(74.83)	18674.6***	(62.40)
80-84	18762.2***	(86.06)	20863.9***	(65.31)
85-89	19947.9***	(108.9)	22153.4***	(75.21)
90+	18867.8***	(128.0)	19986.5***	(96.75)
Mortality rate, females				
0	119988.2***	(11426.8)		
1-4	215537.1***	(15404.9)		
5-9	193107.8***	(23562.0)		
10-14	111588.5***	(22256.4)		
15-19	87140.5***	(15862.7)		
20-24	60250.2***	(13546.0)		
25-29	68019.8***	(12891.9)		
30-34	80850.6***	(12473.2)		
35-39	103846.1***	(10135.8)		
40-44	118871.9***	(8539.3)		
45-49	132076.5***	(6305.6)		
50-54	140986.2***	(4841.1)		
55-59	138076.1***	(3977.4)		
60-64	121013.7***	(3155.1)		
65-69	109558.5***	(2532.2)		
70-74	99365.6***	(2007.7)		
75-79	61976.1***	(1457.7)		
80-84	39107.5***	(1054.5)		
85-89	22423.0***	(793.4)		
90+	5935.6***	(433.9)		
Age, males				
0	25258.4***	(87.76)	25416.9***	(82.57)
1-4	2083.6***	(55.04)	2117.9***	(55.99)
5-9	414.1***	(51.58)	406.2***	(52.67)
10-14	-58.55	(51.59)	-62.93	(52.67)
15-19	439.7***	(52.46)	450.1***	(53.36)
20-24	851.7***	(53.21)	866.0***	(53.87)
25-29	942.3***	(52.30)	960.2***	(52.83)
30-34	1260.5***	(51.06)	1288.3***	(51.53)
35-39	1688.6***	(50.83)	1727.0***	(51.11)
40-44	2271.8***	(51.44)	2396.0***	(51.55)
45-49	3270.4***	(52.58)	3439.2***	(52.22)
50-54	4803.8***	(53.95)	5171.8***	(52.62)
55-59	7079.4***	(56.32)	7745.5***	(53.98)
60-64	10056.5***	(61.13)	11150.9***	(57.09)
65-69	13719.3***	(68.89)	15410.6***	(61.86)
70-74	17608.4***	(76.84)	20003.0***	(65.15)
75-79	21137.3***	(86.98)	24344.5***	(68.33)
80-84	22815.8***	(105.9)	26798.1***	(77.04)
85-89	23798.5***	(140.8)	27894.9***	(100.3)
90+	22599.0***	(197.7)	26229.3***	(154.9)
Mortality rate, males				
0	65412.4***	(9828.8)		
1-4	176742.4***	(15258.7)		
5-9	96843.6***	(17469.4)		
10-14	129338.8***	(19598.0)		
15-19	64229.1***	(9845.1)		
20-24	43107.9***	(7481.1)		
25-29	44369.7***	(7766.7)		
30-34	53933.5***	(7922.2)		
35-39	50064.8***	(7338.8)		
40-44	89489.5***	(6177.9)		

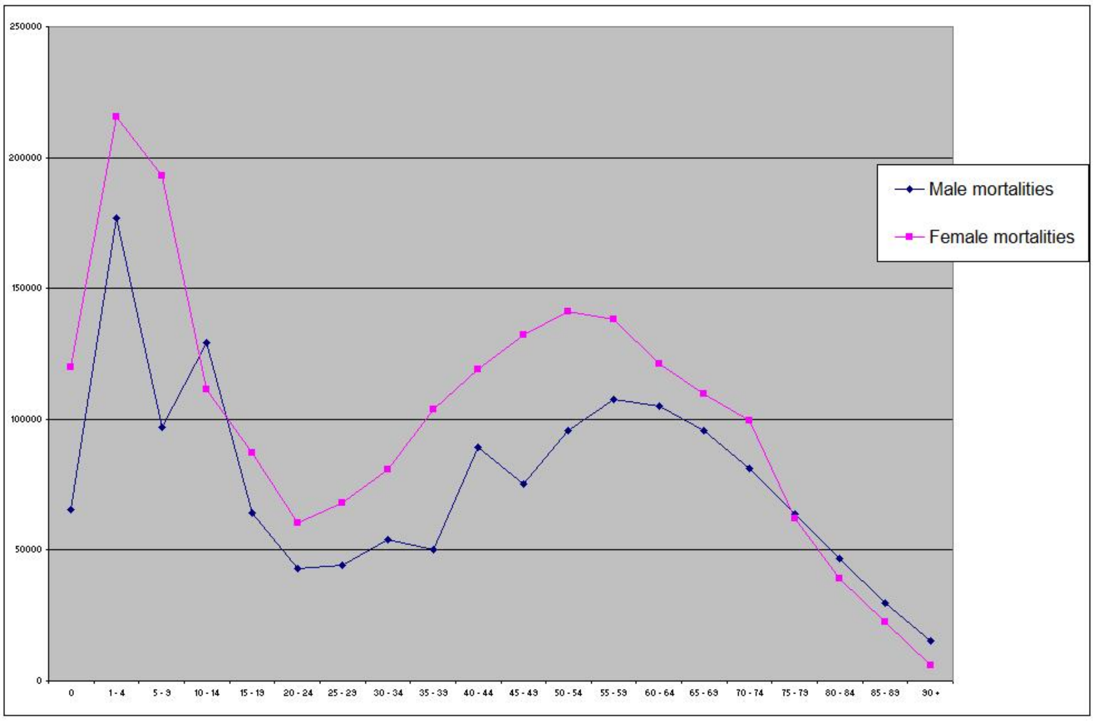
45-49	75365.7***	(4960.4)		
50-54	95812.3***	(3984.0)		
55-59	107490.7***	(3092.0)		
60-64	105001.6***	(2366.4)		
65-69	95870.9***	(1853.0)		
70-74	81194.3***	(1448.1)		
75-79	63649.4***	(1097.0)		
80-84	46879.7***	(863.3)		
85-89	29566.5***	(713.3)		
90+	15246.1***	(525.2)		
Constant	-192.0***	(41.34)	-110.3**	(42.18)
Year:				
1998	Reference group		Reference group	
1999,	542.0***	(24.59)	545.1***	(24.90)
2000	349.6***	(27.28)	335.5***	(27.72)
2001	945.7***	(27.86)	923.0***	(28.34)
2002	1413.9***	(27.96)	1388.9***	(28.47)
2003	1869.4***	(27.96)	1819.3***	(28.46)
2004	1844.2***	(27.93)	1775.5***	(28.43)
2005	2184.7***	(27.89)	2104.8***	(28.39)
2006	2489.5***	(27.82)	2397.9***	(28.33)
2007	2733.4***	(27.77)	2640.3***	(28.27)
2008	2463.6***	(27.66)	2361.0***	(28.16)
2009	2744.9***	(27.68)	2628.1***	(28.18)
N	991930		991930	

* for p<.05, ** for p<.01, and *** for p<.001

As the results show, all the estimated coefficients for both age and mortalities are highly significant, with an exception of males 10-14 (not significantly different from the reference group females 5-9). When excluding mortalities, referred to as the naïve approach in (Häkkinen et al., 2008), also the estimated coefficients for males aged 15-19 and females aged 10-14, becomes insignificant. This point in a direction of rejection of the *Red Herring Hypothesis* (that age may be ignored when estimating trends in health care expenditure). The results also show that mortalities should be included when projecting future health care expenditures.

Based on the regressions presented in table 3, figure 2, show the extra health care expenditures associated with the last year of life. We will refer to this as mortality related expenditure (MRE). The expenditure is highest for the age groups below 60 and declines sharply for the older age groups. Female decedents are more costly than male decedents until the age 75. This is in accordance with the findings in (Melberg, Godager, & Gregersen, 2013).

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



Even though 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. The total expenditures are therefore higher for survivors than decedents, and this holds for all age groups; this is illustrated in table 4. The table is based on the regression presented in table 3 and demographic information from Statistics Norway. In the table 4 we see that even though the estimated MRE, is falling with age, the total share of the hospital expenditures used by decedents is increasing with age, as the total number of decedents is increasing. Further we see that 10% of the total hospital expenditures for males are used by male decedents. The corresponding figure for females is 8%. In the international literature (Hogan, Lunney, Gabel, & Lynn, 2001; Nord, Hjort, & Heiberg, 1989; Polder, Barendregt, & Oers, 2006) the health care expenditures associated with the last year of life is estimated to be somewhere in between 10% and 30% of the total health care expenditure. The studies include different parts of the health care sector and selected part of the population and are therefore often hard to compare.

Table 4 a): Predicted expenditures, males

Age	MRE per capita	# Decedents[b]	Expenditure per capita excluding MRE	# Survivors[b]	Total expenditure for decedents	Total expenditure for survivors	Total Expenditure	Share used by decedents
0	65412	99	26720	29546	9134850	789471450	798606300	1 %
1 - 4	176742	41	3545	119700	7475939	424351357	431827296	2 %
5 - 9	96844	20	1876	154749	1951805	290255069	292206874	1 %
10 - 14	129339	18	1403	155025	2372142	217499794	219871937	1 %
15 - 19	64229	76	1901	146660	5016048	278834060	283850107	2 %
20 - 24	43108	138	2313	140102	6275947	324094117	330370065	2 %
25 - 29	44370	155	2404	151645	7246555	364527779	371774334	2 %
30 - 34	53934	171	2722	169318	9710271	460885561	470595831,4	2 %
35 - 39	50065	216	3150	175762	11481877	553667415	565149291,7	2 %
40 - 44	89489	272	3733	168705	25399701	629835615	655235316	4 %
45 - 49	75366	400	4732	159345	32037707	754018715	786056422	4 %
50 - 54	95812	624	6265	154383	63730449	967257281	1030987730	6 %
55 - 59	107491	885	8541	140005	102661231	1195778635	1298439866	8 %
60 - 64	105002	1196	11518	112995	139307157	1301478131	1440785288	10 %
65 - 69	95871	1528	15181	84350	169637183	1280503534	1450140717	12 %
70 - 74	81194	2169	19070	71367	217428755	1360969540	1578398295	14 %
75 - 79	63649	3262	22599	61207	281352331	1383203425	1664555756	17 %
80 - 84	46880	4002	24277	42468	284803530	1031021669	1315825199	22 %
85 - 89	29566	3406	25260	20653	186745069	521697314	708442384	26 %
90 +	15246	2240	24061	7210	88047348	173479848	261527197	34 %
Sum					1651815896	14302830310	1595464626	10 %

[b]The number of inhabitants and decedents are based on a weighted sum over the years of observations (1998-2009).

Table 4 b): Predicted expenditures females

Age	MRE per capita	# Decedents[b]	Expenditure per capita excluding MRE	# Survivors[b]	Total expenditure for decedents	Total expenditure for survivors	Total Expenditure	Share used by decedents
1 - 4	215537	32	2748	114113	6883914	313620896	320504810	2 %
5 - 9	193108	15	1462	147039	2995437	214904071	217899507	1 %
10 - 14	111589	16	1290	146910	1801225	189534694	191335919	1 %
15 - 19	87140	34	2257	139115	3033863	313994927	317028790	1 %
20 - 24	60250	43	3961	135175	2756823	535455717	538212539	1 %
25 - 29	68020	57	5966	148536	4193986	886172261	890366247	0 %
30 - 34	80851	73	6412	164245	6347027	1053059952	1059406979	1 %
35 - 39	103846	106	5342	168548	11591081	900341742	911932823	1 %
40 - 44	118872	160	4659	161499	19728206	752400369	772128575	3 %
45 - 49	132077	246	5237	153537	33781517	804041885	837823402	4 %
50 - 54	140986	391	6330	148971	57561581	942974534	1000536115	6 %
55 - 59	138076	556	7845	136100	81130839	1067676885	1148807724	7 %
60 - 64	121014	727	9960	113784	95160823	1133243472	1228404295	8 %
65 - 69	109559	901	12329	90846	109836806	1120025202	1229862008	9 %
70 - 74	99366	1397	15136	84050	159912713	1272221423	1432134136	11 %
75 - 79	61976	2504	18313	82121	201014606	1503890623	1704905229	12 %
80 - 84	39107	4028	20224	69874	238962476	1413112666	1652075142	14 %
85 - 89	22423	4974	21409	44403	218008609	950643410	1168652019	19 %
90 +	5936	5456	20329	22095	143297978	449179693	592477671	24 %
Sum					1397999509	15816494421	17214493930	8 %

[b]The number of inhabitants and decedents are based on a weighted sum over the years of observations (1998-2009).

In summary, our results clearly supports that mortalities are, *ceteris paribus*, associated with higher hospital expenditures. It can be showed that if life expectancy increases, then naïve models will produce biased projections of future hospital expenditures. The results also show that even though the decedents have high expenditures on hospital services, the decedents have a small share of the total hospital expenditures.

Policy implications and conclusion

In our analysis we find that 9.2% of all hospital expenditures from 1998 to 2009 were used on individuals in the last calendar year of life. The result is similar to the findings in (Melberg et al., 2013). They find that 10.2% of the hospital expenditures in 2010 in Norway were used on decedents. The difference may come from changes in the demographic composition of the population or other factors such as changes in the actual use of resources on decedents. (Buchner & Wasem, 2006) suggest that there also might be a bias towards treating elderly over time; the steepening effect. This effect may explain the slightly higher share observed in 2010 (Melberg et al., 2013) compared to the period of our observations 1998 to 2009. It is beyond the scope of this paper to investigate steepening any further.

Further our analysis support the inclusion of both mortalities and age in predictions of future hospital expenditure. Thus we conclude that the naïve (age only) approach is insufficient to predict future health care expenditures. Our results, clearly also show that including mortalities alone will not capture the health care expenditures. However, since we use the mortality rate in the last calendar year of life, and not time to death per se, this analysis is insufficient to reject the Red Herring Hypothesis. On the other hand, most of the mortality related expenditure comes in the last three months of life (Emanuel, 1996; Lubitz & Riley, 1993; Melberg et al., 2013; Zweifel et al., 1999), suggesting that the last calendar year of life should be sufficient to capture most of the mortality related expenditures.

We overall, therefore, conclude that mortalities are an important variable when predicting future health care expenditures and stands for a substantial share of the total health care expenditures. Our analyses also clearly show that age also is an important variable when predicting future health care expenditures. Therefore we agree with (Stearns & Norton, 2004) “it is time for time to death”, however, our analysis also suggest it is time for age. 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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Appendix

Table 5: Two stage least squares (2SLS)

Dependent variable	First stage regression, mortality rate		Second stage, regression Per capita expenditure	
Independent variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Age, females				
0	Omitted		Omitted	
1-4	Reference group		Reference group	
5-9	0.000120	(0.000206)	1373.0***	(49.72)
10-14	0.0000193	(0.000192)	-156.4***	(46.38)
15-19	0.000181	(0.000195)	838.3***	(47.06)
20-24	0.000216	(0.000197)	2524.6***	(47.47)
25-29	0.000238	(0.000193)	4587.3***	(46.44)
30-34	0.000284	(0.000188)	5147.6***	(45.26)
35-39	0.000508**	(0.000186)	4027.4***	(44.99)
40-44	0.000833***	(0.000188)	3383.6***	(45.58)
45-49	0.00143***	(0.000190)	4091.2***	(46.55)
50-54	0.00235***	(0.000192)	5331.4***	(48.03)
55-59	0.00376***	(0.000196)	7045.2***	(51.43)
60-64	0.00594***	(0.000205)	9355.3***	(59.20)
65-69	0.00912***	(0.000220)	11906.8***	(72.79)
70-74	0.0152***	(0.000226)	15108.9***	(99.20)
75-79	0.0274***	(0.000229)	18173.5***	(159.6)
80-84	0.0510***	(0.000244)	19477.0***	(284.8)
85-89	0.0949***	(0.000295)	19266.7***	(522.4)
90+	0.189***	(0.000402)	13399.4***	(1030.7)
Age, males				
0	Omitted		Omitted	
1-4	0.000167	(0.000204)	2187.0***	(49.07)
5-9	0.0000137	(0.000190)	414.9***	(45.89)
10-14	0.0000306	(0.000190)	-27.98	(45.77)
15-19	0.000444*	(0.000193)	530.8***	(46.48)
20-24	0.000812***	(0.000195)	958.2***	(47.22)
25-29	0.000837***	(0.000192)	1017.4***	(46.41)
30-34	0.000816***	(0.000186)	1372.6***	(45.15)
35-39	0.00106***	(0.000185)	1823.3***	(44.84)
40-44	0.00142***	(0.000186)	2487.7***	(45.55)
45-49	0.00223***	(0.000189)	3488.4***	(47.10)
50-54	0.00366***	(0.000190)	5177.6***	(50.05)
55-59	0.00582***	(0.000194)	7725.1***	(56.62)
60-64	0.00967***	(0.000206)	11064.1***	(72.50)
65-69	0.0164***	(0.000225)	15121.2***	(104.9)
70-74	0.0272***	(0.000239)	19440.6***	(159.4)
75-79	0.0468***	(0.000255)	23186.1***	(262.8)
80-84	0.0804***	(0.000296)	24534.1***	(444.8)
85-89	0.133***	(0.000397)	23827.6***	(730.7)
90	0.228***	(0.000594)	18227.9***	(1239.7)
Lagged mortality rate	0.0634***	(0.00136)		
Mortality rate			33907.9***	(5165.2)
Constant	0.00116***	(0.000157)	434.0***	(38.44)
Year				
1998	Referece year		Reference year	
1999	Omitted		Omitted	
2000	-0.000337**	(0.000117)	-215.8***	(28.14)
2001	-0.000457***	(0.000116)	313.8***	(28.16)
2002	-0.000465***	(0.000116)	591.9***	(28.13)
2003	-0.000943***	(0.000116)	1029.6***	(28.42)
2004	-0.00129***	(0.000116)	967.9***	(28.78)
2005	-0.00144***	(0.000116)	1287.8***	(28.97)
2006	-0.00158***	(0.000116)	1556.6***	(29.13)
2007	-0.00155***	(0.000115)	1747.0***	(29.03)
2008	-0.00172***	(0.000115)	1529.8***	(29.23)
2009	-0.00193***	(0.000114)	1937.1***	(29.49)
Number of observations	902384		902384	
R-sq	0.564		0.597	
adj. R-sq	0.564		0.597	
	F(48,902335)=24311.83			

* for p<.05, ** for p<.01, and *** for p<.001

Tests of endogeneity:
Ho: variables are exogenous

Durbin (score) chi2(1) =	.022491	(p	=	0.8808)		
Wu-Hausman F(1,902334)	=	.02249	(p	=	0.8808)	

Table 6: Results from weighted least squares regression

Dependent variable	**Per capita expenditures**		**Per capita expenditures**	
Independent variable	**Independent variables including mortalities**		**Independent variables excluding mortalities**	
	Coefficient	Standard error	Coefficient	Standard error
Age, females				
0	24794.9***	(84.63)	25067.2***	(80.42)
1-4	1330.8***	(48.18)	1373.9***	(48.77)
5-9	Reference group		Reference group	
10-14	-167.4***	(44.95)	-173.6***	(45.63)
15-19	816.7***	(45.70)	821.8***	(46.27)
20-24	2544.7***	(46.02)	2548.0***	(46.56)
25-29	4628.8***	(45.02)	4633.9***	(45.46)
30-34	5108.2***	(44.05)	5125.8***	(44.39)
35-39	3903.5***	(43.94)	3963.0***	(44.14)
40-44	3193.6***	(44.70)	3308.9***	(44.56)
45-49	3793.4***	(45.63)	4023.7***	(45.10)
50-54	4875.2***	(46.64)	5286.1***	(45.43)
55-59	6378.2***	(48.79)	7014.9***	(46.48)
60-64	8457.2***	(52.36)	9345.7***	(48.79)
65-69	10769.6***	(57.37)	11986.2***	(51.96)
70-74	13566.5***	(62.60)	15366.5***	(53.14)
75-79	16806.8***	(69.20)	18807.7***	(53.36)
80-84	18694.3***	(81.38)	20989.2***	(55.80)
85-89	19901.4***	(104.8)	22327.0***	(64.34)
90+	18821.3***	(118.8)	19799.8***	(81.07)
Mortality rate, females				
0	112183.9***	(11543.2)		
1-4	233138.6***	(16279.4)		
5-9	222565.3***	(24942.9)		
10-14	140610.1***	(23454.3)		
15-19	99889.3***	(16731.6)		
20-24	79887.0***	(14272.6)		
25-29	80108.0***	(13607.6)		
30-34	96335.5***	(13177.5)		
35-39	128477.8***	(10713.8)		
40-44	139181.3***	(8927.7)		
45-49	156729.2***	(6645.8)		
50-54	164526.9***	(5077.8)		
55-59	161398.4***	(4190.4)		
60-64	143094.3***	(3316.5)		
65-69	126461.1***	(2668.1)		
70-74	111626.2***	(2108.7)		
75-79	68682.8***	(1529.2)		
80-84	42490.3***	(1101.7)		
85-89	24191.7***	(827.2)		
90+	4996.1***	(442.2)		
Male age				
0	26745.2***	(83.83)	26964.1***	(78.69)
1-4	2138.6***	(47.65)	2179.7***	(48.12)
5-9	406.5***	(44.36)	398.6***	(45.04)
10-14	-45.92	(44.36)	-48.88	(45.03)
15-19	506.6***	(45.22)	524.5***	(45.65)
20-24	934.0***	(46.01)	959.0***	(46.12)
25-29	997.5***	(45.26)	1023.7***	(45.22)
30-34	1320.2***	(44.17)	1364.5***	(44.06)
35-39	1725.9***	(44.01)	1797.3***	(43.70)
40-44	2321.3***	(44.65)	2463.3***	(44.10)
45-49	3287.7***	(45.84)	3483.8***	(44.68)
50-54	4778.3***	(47.40)	5214.5***	(45.01)
55-59	7056.1***	(49.81)	7804.9***	(46.13)
60-64	10018.4***	(54.63)	11243.7***	(48.84)
65-69	13608.2***	(62.53)	15499.2***	(53.03)
70-74	17479.6***	(70.82)	20117.3***	(55.79)
75-79	21047.1***	(81.51)	24514.7***	(58.42)
80-84	22673.1***	(100.9)	26990.3***	(65.85)
85-89	23569.1***	(134.6)	28072.7***	(86.01)
90+	21948.7***	(181.9)	25772.5***	(130.9)
Male mortalities				
0	71657.7***	(9620.7)		
1-4	187020.9***	(16109.4)		
5-9	123983.2***	(18380.9)		
10-14	154748.3***	(20657.6)		
15-19	72229.0***	(10392.7)		
20-24	48657.6***	(7872.0)		
25-29	50386.2***	(8195.5)		

30-34	68306.3***	(8360.5)		
35-39	75321.6***	(7606.8)		
40-44	100512.4***	(6519.8)		
45-49	87486.3***	(5227.3)		
50-54	113624.1***	(4191.4)		
55-59	121751.9***	(3259.8)		
60-64	118649.0***	(2489.9)		
65-69	107850.2***	(1949.2)		
70-74	90191.7***	(1518.0)		
75-79	69157.6***	(1145.5)		
80-84	50378.7***	(899.2)		
85-89	32014.0***	(741.5)		
90+	16106.4***	(539.6)		
Constant	-241.8***	(37.07)	-148.8***	(37.66)
Year				
1998	Reference group		Reference group	
1999	544.0***	(28.20)	541.8***	(28.72)
2000	342.2***	(28.15)	319.1***	(28.67)
2001	898.2***	(28.12)	863.3***	(28.63)
2002	1365.6***	(28.08)	1327.7***	(28.60)
2003	1815.8***	(28.04)	1749.6***	(28.56)
2004	1788.7***	(28.01)	1701.8***	(28.52)
2005	2124.1***	(27.97)	2024.5***	(28.48)
2006	2417.6***	(27.90)	2304.6***	(28.41)
2007	2674.0***	(27.84)	2559.9***	(28.35)
2008	2436.6***	(27.73)	2313.7***	(28.23)
2009	2862.1***	(27.65)	2724.5***	(28.15)
N	995158		995158	
R-sq	0.767		0.758	
adj. R-sq	0.767		0.758	

* for p<.05, ** for p<.01, and *** for p<.001