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IBS Working Paper 05/2015

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Abstract

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Keywords: healthcare expenditure, ageing, red herring, death related costs

JEL Classification Numbers: H51, I12, I18, J14

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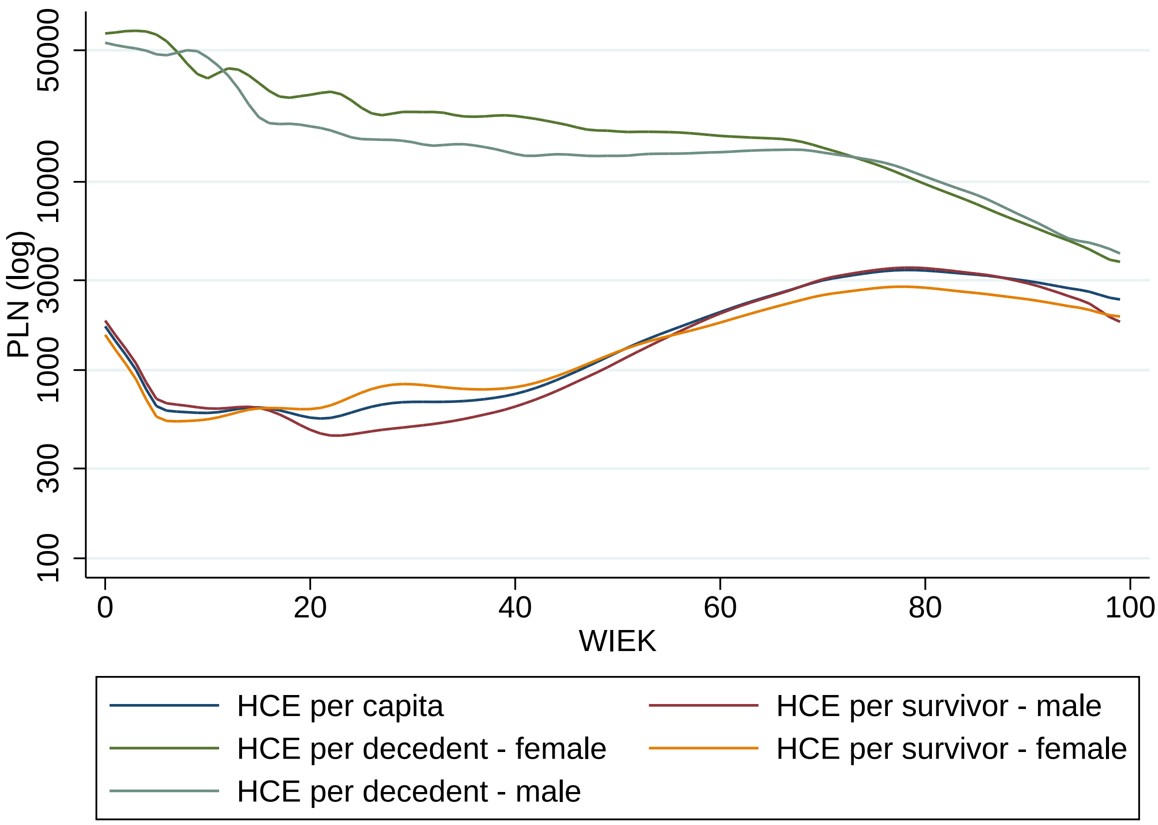
1 Introduction

The dependency of HCE on age seems trivial when the distribution of health care expenditure by age is studied. It forms a well-known turned S shape. High expenditure in the first years of life precedes a period of low expenditure which gradually rises after the age of 40. On the contrary, a more careful examination reveals that death-related costs drop in the course of a person's lifespan. As a consequence, rising expenditure with age is a combination of the rising costs for survivors and the rising mortality rate (Figure 1). Looking at gender differences allows us to conclude that the higher expenditure for females is a result of pregnancy-related costs and the fact that more attention is paid to their health. The per capita expenditure equals the mean spendings of a 56-year old person (1693 PLN, ca 400 EURO, 2012). They vary 6-fold from the most to the least expensive age groups. Due to the predominant share of survivors, they influence the shape of the age-profile most of all.

Figure 1: Distribution of HCE by age (logarythmic scale)



Source: Own calculation.

There are three general patterns of morbidity changes with age: (1) progressive illness, (2) catastrophic events, (3) gradual progressive functional decline (Vellas et al., 1992). They can all rise as a result of more and more procedures per capita, as well as the increasing cost of procedures with age. However, we would expect progressive illnesses to affect the frequency of health care use, catastrophic events to limit the cost of procedures and the functional decline to limit the commonness of health care use.
We quantify the role of the decedents' share of the population as well as the frequency, prevalence and the cost of procedures in the increase in health care costs with age. Firstly we provide a brief overview of the relevant literature, we then present the decomposition methods and finally we show the results of the total decomposition as well as selected types of health care costs

2 Literature

The changes in the age structure of HCE are a reflection of the changes in morbidity rates and the health care procedures used for illnesses. Michel and Robine (2004) provide three contradictory examples of the evolution of morbidity and mortality rates. The increase in the survivor rates of sick people resulted in a rise of morbidity and disability rates in Taiwan, whereas a fall in the mortality rate was accompanied by an increase in disability in the UK, a reduction in morbidity and disability rates in France, Switzerland and the US. The generalization of this evolution is described in terms of demographic and epidemiological change. At the first stage of this evolution, the positive shock to mortality means that more people survive but increases disability rates. Then, the cohorts live longer in a good health condition, but eventually the life-expectancy extends so much that disability rises in later years of life.
As pointed out by Michel and Robine (2004) the recent increase in life expectancy in developed countries is due to a reduction in mortality rates later in life. There are three main hypotheses about the changes in morbidity patterns: expansion, compression and postponement (Fries, 2002; Kramer, 1980; Payne et al., 2007). The first assumes that rising longevity leads to a prolonging of the duration of illness or disability. The compression hypothesis postulates that the duration of bad health would fall, while the final hypothesis states that the period of life in which the person suffers from disability or

illness would just be moved forward. Recent evidence has delivered a mild argument in favour of the compression hypothesis (de Meijer et al., 2013; Martin et al., 2010; Christensen et al., 2009; Lafortune and Balestat, 2013; Parker and Thorslund, 2007).

Introducing time-to-death as a determinant of health care expenditure delivers further insights into the problem. Most studies from various countries agree with the view that both age and time-to-death play a role in explaining health expenditure. Yang et al. (2003) have delivered in-depth descriptive analyses of US health expenditure data. They have shown that spending rises significantly in the last 6 months of life. The proximity to death is a good predictor of inpatient care, but age is a better way of explaining the use of long-term health care. Karlsson and Klohn (2011) have delivered evidence about long-term care based on Swedish administrative data. They found strong support for the effect of the time-to-death (*red herring hypothesis*) but also the important effects of age. Weaver et al. (2009) have shown that the proximity to death is the main driver for long-term health care expenditure in US. For Italy, Atella and Conti (2013) have delivered evidence that the time to death is a good predictor of outpatient care, but does not eliminate the influence of age. Seshamani and Gray (2004) show that the difference in inpatient care expenditure remains significant even 13 years before death, although age is an important factor as well.

By widening the analytical approach, Shang and Goldman (2008) have tried to deal with the issue by suggesting that life expectancy is based on socio-economic characteristics. They have confirmed that both age and proximity to death are important drivers of HCE in the US. de Meijer et al. (2011) elaborated in detail about the health care costs after surviving specific diseases in the Netherlands. They analysed the main causes of LTC, especially the histories of specific diseases, disabilities and co-residence. They found that that when controlling for disability and co-residence, the time-to-death (TTD) loses its significance for LTC while the age remains significant. Polder et al. (2006) have added a new insight to the understanding of death determinants in the Netherlands. They found that the variety of causes of death within the age groups is much greater than between groups. This contradicts the view that differences in causes of death drive the age dynamics of costs. Additionally, most expensive death cause is cancer and the cheapest are heart diseases (Lubitz et al., 2003). Wong et al. (2011) have analysed hospital expenditure by type of disease. They found, that in some cases it is age that matters while in others it is the proximity to death. Werblow et al. (2007) have looked into the influence of the proximity to death on the various components of HCE in Switzerland. Except for LTC they found little evidence of age being significant.

3 Data

For our analysis, a unique dataset of 14 types of HCE by age, sex and differentiated by decedents and survivors has been provided by the Polish National Health Fund (NFZ). It covers 80% of public HCE and almost half of all spending in Poland, and includes in and outpatient care, some long-term care as well as drug refunding. There is no selection issue as 98% of the Polish population is entitled to public health care. Firstly, we smooth all the age distributions using a kernel smoother and then decompose the one year age group differences of HCE as a result of changes in death-related costs, patient to survivor ratio, death rate and population size. This enables the non-linear dependence of the drivers of health costs to be checked.

The data was obtained from the Polish National Heath Fund (NFZ). It contains most of the NFZ spending with breakdowns for sex, age, type (e. g. inpatient, outpatient and drugs) and information about whether the person died in the given year. The NFZ finances about 60% of HCE in Poland, with an additional 10

4 Decomposition methods

By applying a specific decomposition, we can look at the age-expenditure in detail and deliver arguments in favour of or against the *red herring* hypothesis. If the rise in health expenditure with age is incurred due to the rising costs of survivors, we can expect the HCE to be more age-dependent. If the rise is down to a rising mortality rate and expenditure on decedents, this is a strong argument in favour of the *red herring* hypothesis. The formal definition of the decomposition is delivered below.

A cohort at the age of a consists of those dying this year $P_a^{d,a}$, next year $P_a^{d,a+1}$, and surviving next year P_a^s. Consequently, the health care costs are split for three parts respectively.

$$H_a = H_a^{d,a} + H_a^{d,a+1} + H_a^s \tag{1}$$

The stable age-specific mortality rates allow us to notice that the health care expenditure (H_a) of cohort a at year t equals:

$$\begin{aligned} H_a \quad = \quad P_a h_a \quad = \quad P_a^s h_a^s + P_a^{d,a+1} h_a^{d,a+1} + P_a^{d,a} h_a^{d,a} \quad = \\ (1-d_a)(1-d_{a+1}) P_a h_a^s + (1-d_a) d_{a+1} P_a h_a^{d,a+1} + d_a \, P_a \, h_a^{d,a} \end{aligned} \tag{2}$$

where: P_a is the size of the population at age a, h_a^s is the health expenditure per survivor, $h_a^{d,a+1}$ stands for the health expenditure per decedent next year, $h_a^{d,a}$ health expenditure per decedent this year and d_a for the death rate at age a. All values can be directly derived from the data except for $h_a^{d,a+1}$ and h_a^s. We can, however, show the upper and lower threshold values for these values. The dataset enables the population of a given age to be divided into those dying and surviving each year. Decedents in t could have died between January and December, meaning that they generated expenditure for 1 to 12 months. Their mean timespan of health care utilization is therefore 6 months, provided there is a constant death rate of a cohort in a given year. Similarly, for those surviving t and dying in $t+1$, the life expectancy and duration of use of health care in given year at the beginning of t is 18 months. If expenditure rises monotonically until death there are two borderline cases:

- HCE in t per decedent in $t+1$ is the same as for survivors in $t : h_a^{d,a} = h_a^{s,a}$.
- HCE in t per decedent in $t+1$ are two times higher than for decedents in $t+1 :$ $h_a^{d,a+1} = 2h_a^{d,a+1}$.

In the basic decomposition we will make an assumption against the *red herring* hypothesis. As a result only the costs in the year of death will be included. This is a strict assumption, as Zweifel et al. (2004) have reported that the monthly dummy variables are significant for 12 months before death. Moreover, Yang et al. (2003) have shown that the HCE starts to rise exponentially about 6 months before death, doubling 3 months and quadrupling in the last month of life. On top of that Atella and Conti (2013) have shown, for Italy and for outpatient costs, that the costs incurred by survivors and decedents do not differ 3 years before death.

Assuming that all variables in equation 2 are continuous functions of time, and applying a total derivative with respect to time, we get the following:

$$\begin{aligned} \mathrm{d}H = \frac{\partial H}{\partial d_a}\,\mathrm{d}d_a + \frac{\partial H}{\partial d_{a+1}}\,\mathrm{d}d_{a+1} + \frac{\partial H}{\partial P_a}\,\mathrm{d}P_a + \\ \frac{\partial H}{\partial h_a^s}\,\mathrm{d}h_a^s + \frac{\partial H}{\partial h_a^{d,a}}\,\mathrm{d}h_a^{d,a} + \frac{\partial H}{\partial h_a^{d,a+1}}\,\mathrm{d}h_a^{d,a+1} \end{aligned} \tag{3}$$

Defining $\Delta x = x_{a+1} - x_a$ for any x we come up with approximations:

$HPS_a = \Delta h_a^s \quad (1-d_a)(1-d_{a+1})P_a$

$HPD_a = \Delta h_a^{d,a} \quad d_a P_a \ + \ \Delta h_a^{d,a+1} \quad (1-d_a)d_{a+1}P_a$

$DR_a = \Delta d_a \quad \big(-(1-d_{a+1})P_a h_a^s - d_{a+1}P_a h_a^{d,a+1} + P_a h_a^{d,a}\big) +$

$\Delta d_{a+1} \quad \big(-(1-d_a)P_a h_a^s + (1-d_a)P_a h_a^{d,a+1}\big)$

$DRP_a = d_a P_a \quad \big((1-d_a)(1-d_{a+1})h_a^s + (1-d_a)d_{a+1}h_a^{d,a+1} + d_a h_a^{d,a}\big)$

$CS_a = (\Delta P_a - d_a P_a) \quad \big((1-d_a)(1-d_{a+1})h_a^s + (1-d_a)d_{a+1}h_a^{d,a+1} + d_a h_a^{d,a}\big)$

The new variables are interpreted as the contribution of changes to:

- expenditure per decedent this year and next year - (HPD_a),
- expenditure per survivor for years t and $t+1$ - (HPS_a),
- share of decedents (death rate) in t and $t+1$ - (DR_a),
- population due to mortality (DRP_a) and cohort size - (CS_a).

Further investigation helped us understand more details about the drivers of health costs for specific types of care. In addition to the role of decedents and survivors, we also distinguish between the contribution costs per incidence of care use, the number of incidences per user and the number of users of any health care or selected type of care. To make things clear, we limit the analysis to current year decedents. We therefore observe that:

$$\begin{aligned} H_a = (H_a^s/I_a^s)(I_a^s/U_a^s)(U_a^s/P_a^s)(P_a^s/P_a)P_a + \\ (H_a^{d,a}/I_a^{d,a})(I_a^{d,a}/U_a^{d,a})(U_a^{d,a}/P_a^{d,a})(P_a^{d,a}/P_a)P_a \end{aligned} \tag{4}$$

Assigning $h_a^{s,u}$ as expenditure per incident among survivors, i_a^s incidences per survivor user, u_a^s as the share of users amongst survivors and suitably for decedents, as well as d_a as the decedent share (death rate) and P as population we get the following:

$$H_a = h_a^{s,u} i_a^s u_a^s (1-d_a)P_a \ + \ h_a^{d,u} i_a^d u_a^d d_a P_a \tag{5}$$

With the same assumptions as to Equation 3 we get:

$$\begin{aligned} \mathrm{d}H = & \frac{\partial H}{\partial h^{s,u}}\,\mathrm{d}h^{s,u} + \frac{\partial H}{\partial i_a^s}\,\mathrm{d}i_a^s + \frac{\partial H}{\partial u_a^s}\,\mathrm{d}u_a^s + \frac{\partial H}{\partial h_a^{d,u}}\,\mathrm{d}h_a^{d,u} + \\ & \frac{\partial H}{\partial i_a^d}\,\mathrm{d}i_a^d + \frac{\partial H}{\partial u_a^d}\,\mathrm{d}u_a^d + \frac{\partial H}{\partial d_a}\,\mathrm{d}d_a + \frac{\partial H}{\partial P_a}\,\mathrm{d}P_a \end{aligned} \tag{6}$$

Applying the same procedure as above we can define:

$HPIS_a = \Delta h_a^{s,u} \quad i_a^s u_a^s (1-d_a)P_a$

$HPID_a = \Delta h_a^{d,u} \quad i_a^d u_a^d d_a P_a$

$IPUS_a = \Delta i_a^d \quad h_a^{s,u} u_a^s (1-d_a)P_a$

$IPUD_a = \Delta i_a^d \quad h_a^{d,u} u_a^d d_a P_a$

$USR_a = \Delta u_a^s \quad h_a^{s,u} i_a^s (1-d_a)P_a$

$UDR_a = \Delta u_a^d \quad h_a^{d,u} i_a^d d_a P_a$

$DR_a = \Delta d_a \quad \big(-h_a^{s,u} i_a^s u_a^s P_a + h_a^{d,u} i_a^d u_a^d P_a\big)$

$DRP_a = d_a P_a \quad \big(h_a^{s,u} i_a^s u_a^s (1-d_a) + h_a^{d,u} i_a^d u_a^d d_a\big)$

$CS_a = (\Delta P_a - d_a P_a)\,\big(h_a^{s,u} i_a^s u_a^s (1-d_a) + h_a^{d,u} i_a^d u_a^d d_a\big)$

These variables are interpreted as the contributions to age differences in HCE of changes to:

- expenditure per incident, survivor user - ($HPIS_a$),
- expenditure per incident, decedent user - ($HPID_a$),
- incident per survivor user - ($IPUS_a$),
- incident per decedent user - ($IPUD_a$),
- user ratio among survivals - (USR_a),
- user ratio among decedents - (UDR_a),
- share of decedents (death rate) - (DR_a),
- population size due to mortality (DRP_a) and cohort size (CS_a).

All decompositions are calculated after smoothing the age profiles using the kernel-smoother. The differences between consecutive cohorts are divided by the mean cohort expenditure ($HCE/100$) in order to enable a comparison on an interpretable scale. The results can therefore be interpreted as changes in relation to the mean cohort expenditure.

5 Results

More precise evidence of the main driving forces of rising HCE with age is provided by the decomposition of the inter-cohort differences between consecutive 1-year age groups. The total cohort expenditure is divided by the mean cohort expenditure in order to present the magnitude of the inter-age group differences and the impact of the death rate on the expenditure on a more interpretable scale.

The role of health expenditure drivers evolves with age (see Figure 2 and Table 1). After infancy expenditure drops sharply among survivors and then remains stable until the age of 35. From the age of 35 to 60 it rises at an accelerating rate, mainly due to rising expenditure per user and the number of users in the population. It is much more important that more people using health care more often, than the fact that the procedures are becoming more expensive. From the age of 50 to 70 the per capita expenditure rises by almost 10% a year. On the other hand, the rising death rate is the factor that stops costs from exploding. The rising amount of treatment and the share of decedents play a minor role as long as we do not assume that the costs incurred in the year before death are twice as big as those incurred in the last year of life. Thereafter the rate of growth declines, firstly due to declining expenditure per survivor, and later per decedent. Cohorts older than 70 generate lower costs, as the reduction of the size of the cohort due to deaths becomes the main inhibiting factor. This continues to dominate until the age of 100. From the age of 80 the decline of costs generated by decedents and survivors is outbalanced by the rising share of the former. The incidence does not play a major role in total expenditure, as any contact with health care financed by NFZ is counted, without differentiation between surgery or a flu-related visit (see Figure 2 and Table 2). Without a strong assumption of the high expenditure even two years before death, it is mainly survivors and not decedents that drive the differences in HCE among the age-groups. Distinguishing the costs of this year's decedents and survivors show that it is age that mainly drives the costs. However, taking into account the longer time period

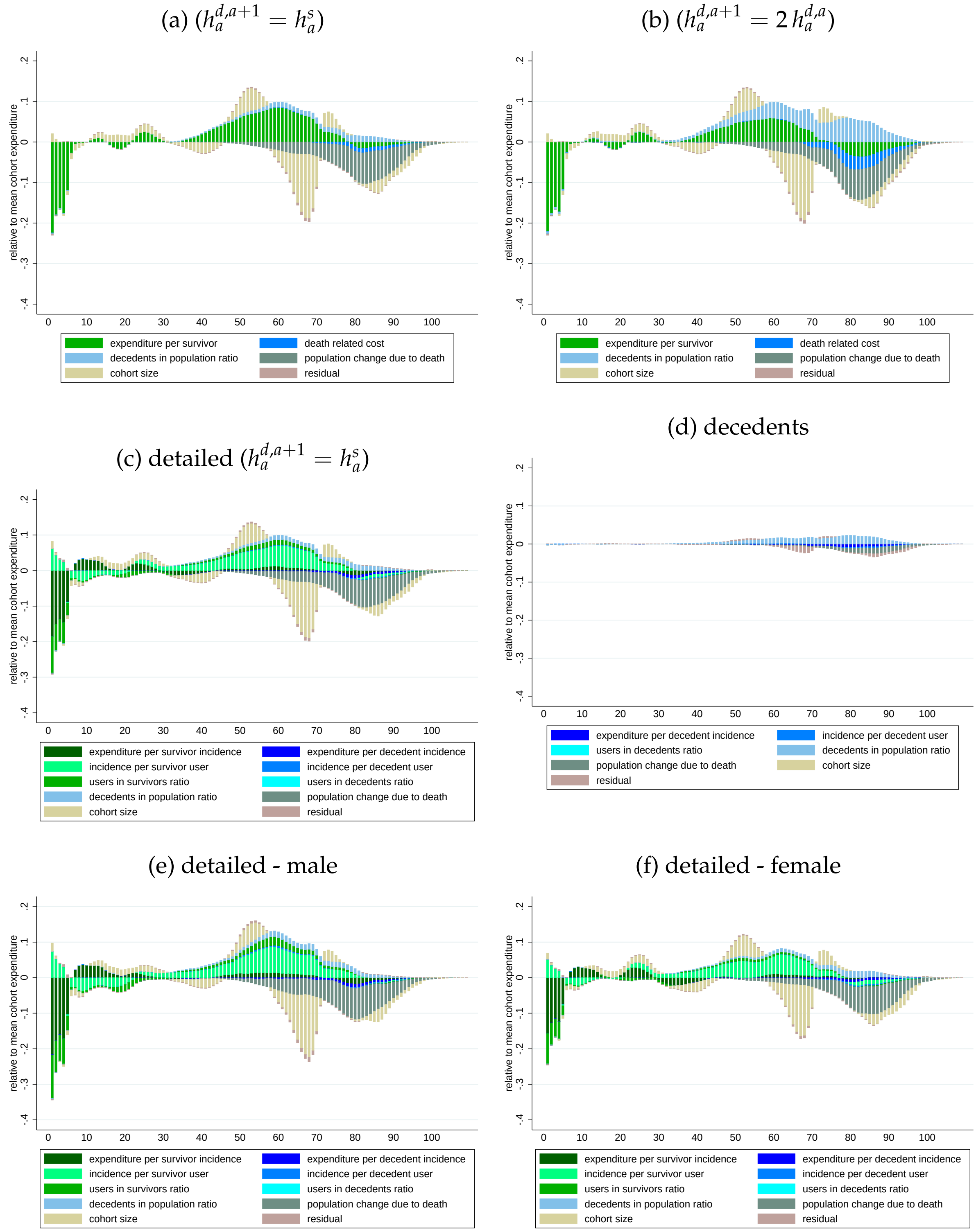
before death, this could change the conclusion in favour of the *red herring* hypothesis.
The driving forces of HCE among men and women remain similar, with men having a steeper profile and more importance placed on the users-in-survival rate. The cohort differences are almost twice as high. This is an effect of the lower tendency and need of men to use health care without serious health problems. We would therefore expect a stronger influence of death-related costs here than amongst women.

Yang et al. (2003) have presented the months-to-death profiles from the US, with expenditure doubling in the last 3 months before death, and rising slightly for 7-4 months before. We therefore expect the HCE of those dying next year to be closer to the survivors than to the expenditure of those who died this year. In fact, even assuming that the level of expenditure is the same 2 years before death as it was in the last year of life, the growth of expenditure per capita in the age period from 40-65 would dominate any other effects. Consequently, we can observe evidence against the strong version of *red herring* - age matters here and is a more important driver for the rise in expenditure than the costs incurred up to two years before death. The *red herring* investigation using individual data and neglecting the cohort dimension leaves one important channel of the rise in costs. The outlay on survivors seems to dominate the differences in health between the age groups.

The relationship between HCE and age is non-linear. Consequently it is important to distinguish age groups that are as small as possible. For people aged 35-65 there is almost linear relation between age, health expenditure, mortality rate and life expectancy. In the later stages of life the difference in outlays for decedents and survivors fade away, which might be a result of the drop in life expectancy. It is important to note however, that any decrease in death rates at any age would lead to an increase in total expenditure in consecutive years due to rising expenditure per survivor until the age of 70.

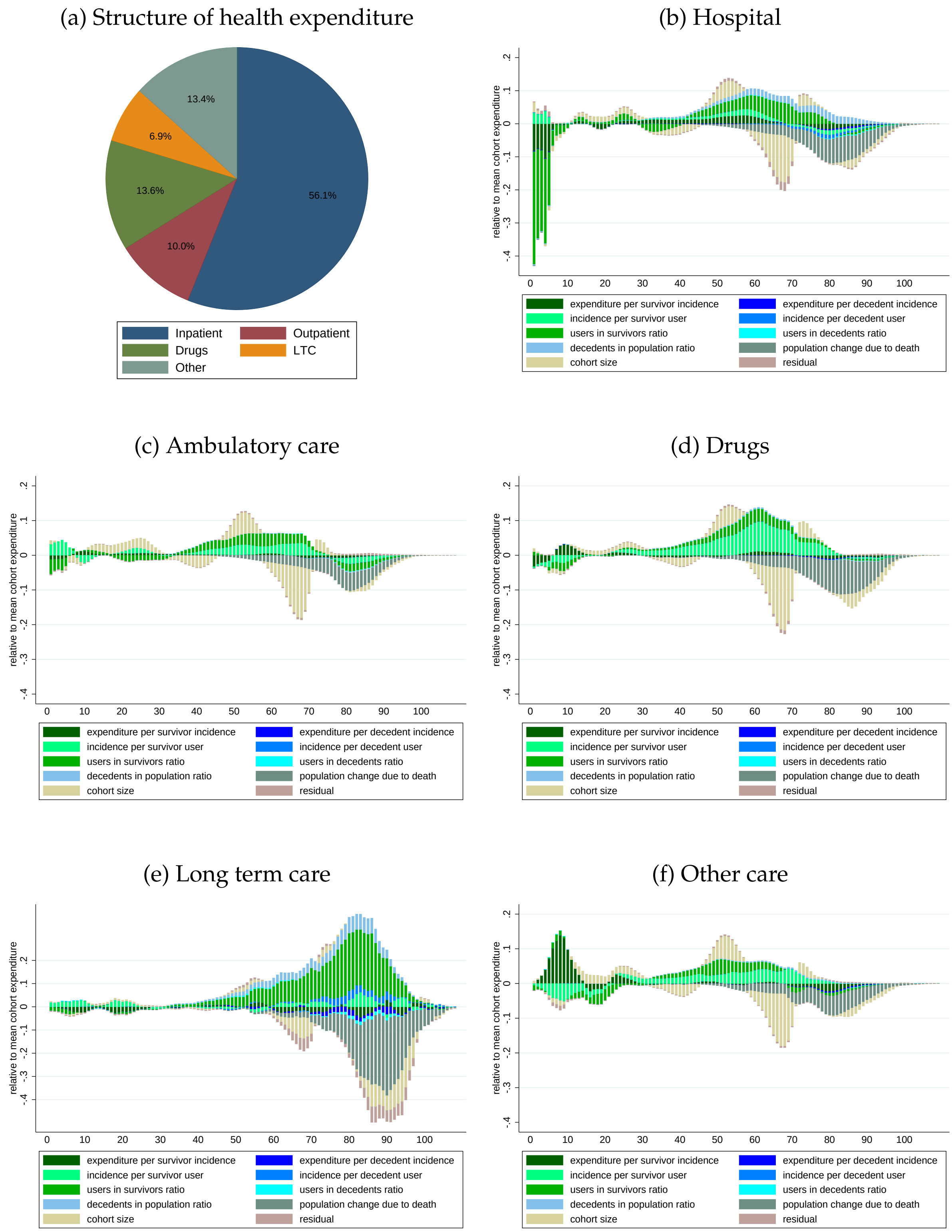
The dynamics of total expenditure are affected by changes to the components. Inpatient care takes the highest share of expenditure, followed by drug refinancing. Long-term health care financed by the NFZ mostly covers institutional care (hospices) which are characterised by their strict age-dependence. Most of the studies on health care expenditure concentrate on hospital costs, as they are the most widely available and constitute the vast majority of the total costs (Zweifel et al., 2004).

Figure 2: Decomposition of total health expenditure differences by age



Source: Own calculation.

Figure 3: Decomposition of health expenditure differences by age and type



Source: Own calculation.

Table 1: Extracted, cumulated effects of HCE drivers as % of mean cohort expenditure

Assumption	Age	exp. per survivor	exp. per decedent	decedent share	pop. change due to death	cohort size	residual
$h_a^{d,a+1} = h_a^s$	0-30	-81.1	-0.7	0.1	-0.6	26.3	0.1
$h_a^{d,a+1} = 2\,h_a^{d,a}$	0-30	-80.4	-2	0.8	-0.6	26.3	0
$h_a^{d,a+1} = h_a^s$	31-75	204.6	-1.5	33.9	-66.9	-79.4	-5.4
$h_a^{d,a+1} = 2\,h_a^{d,a}$	31-75	134.7	-12	113	-66.7	-79.2	-4.7
$h_a^{d,a+1} = h_a^s$	76-100	-12.6	-16	21.2	-119.9	-23.8	-1.2
$h_a^{d,a+1} = 2\,h_a^{d,a}$	76-100	-44.2	-47.1	79.3	-115.7	-22.5	-2.4

Table 2: Extracted, cumulated effects of HCE drivers by type of care as % of mean cohort expenditure of given type

Expenditure Type	age	exp. per surv. inc.	exp. per dec. inc.	inc. per surv. user	inc. per dec. user	users in surv.	users in dec.	decedents' share	pop. change due to death	cohort size	residual
Total	0-30	-32.8	-0.8	-1.3	0.2	-59	1.3	-1.4	-1	40.3	-0.6
Total-male	0-30	-43.3	-0.7	-15.6	-0.1	-71.7	1.5	-1.1	-1.4	38.9	-1.6
Total-female	0-30	-21.2	-0.8	8.5	0.5	-47.8	1.3	-1.7	-0.6	41.7	0.3
Hospital	0-30	-42.6	-1.7	17.6	0.6	-137.2	2.4	-2.5	-1.2	39.1	4.8
Ambulatory care	0-30	9.4	0	23.5	0	-45.5	0	0	-1.2	53.5	-2.2
LTC	0-30	-39.8	-0.1	39	-0.2	-18.2	0.9	-0.7	-0.3	12.7	-4.1
Drugs	0-30	12.9	0.1	-10.4	0	-19.4	0	0.1	-0.7	25.9	-0.4
Other	0-30	91.8	0.1	-43.8	0	-43.7	0.1	0	-0.9	49.1	-7.6
Total	31-75	7.2	-8.4	163.3	4.7	52.1	3.5	31.9	-74.1	-89.7	-5.3
Total-male	31-75	25.5	-11.2	182.5	9.3	70.1	5.6	40.2	-111.9	-106.6	-8.2
Total-female	31-75	-5.1	-5.8	148	0	36.2	1.3	27.5	-45.4	-76.3	-3.8
Hospital	31-75	56	-2.7	30.3	-7.4	123.4	8.4	49.7	-73.7	-81.9	-14.5
Ambulatory care	31-75	3.4	-0.4	79.3	-0.2	108.1	0.6	-0.5	-70.8	-85.2	-2.9
LTC	31-75	-20.4	-12.2	8.3	12.8	273	16.4	82.9	-60.8	-46.8	-34.6
Drugs	31-75	1.4	-3	207.4	1.1	110.3	2.7	6.6	-82.6	-102.4	-5.5
Other	31-75	-3.6	-2.1	115.7	1	89.9	1.9	6.9	-72.5	-86	-2.2
Total	76-100	-10.9	-11.8	-3	-4.4	17.4	3.4	20.6	-135	-26.2	-1.8
Total-male	76-100	-17.3	-11.6	7.1	-3.2	17.6	3.6	16.6	-145.6	-26.3	-1.8
Total-female	76-100	-1.2	-11.6	-10.5	-5.5	19.2	3.9	25.6	-140.2	-32.4	-3
Hospital	76-100	-17.6	-7.9	-14.3	-13.2	21	-0.1	33.9	-140.2	-22.9	-6.8
Ambulatory care	76-100	-7.7	-0.6	-20	-1	-12.9	-1.2	-5.1	-81	-13.6	6.2
LTC	76-100	-18.5	-38.3	47.5	56.7	468.7	-3.8	99	-579.2	-125.6	-110.9
Drugs	76-100	-13.4	-3.7	11.6	-1.8	26.8	1.4	-4.6	-179.2	-37.6	0.1
Other	76-100	-21.2	-5.7	3.2	-1.2	7.8	2	2.8	-104.3	-20.9	0.1

Source: Own calculation.

The age profile of hospital expenditure is similar to the profile of all expenditure. It can be observed that the rising ratio of patients drives expenditure after the age of 50, to a greater extent than the rising expenditure per patient. The role of death increases with age. After the age of 65, the expenditure per survivor remains stable and the costs are driven by the rising death rate. However, this is outweighed by the drop in death-related costs after the age of 60. As they get older, people use health services more often. The rising costs of individual health care over age play a minor role in the rise of health care expenditure with age.

On the other hand, outpatient care and drug use are hardly driven by decedents, even though the expenditure rises significantly with age. Long-term health care costs are driven mainly by the share of decedents. However, it is important to notice that these are the only LTC financed by the NFZ, and only represent a fraction of the total.

In summary, at the age of 65 expenditure per survivor stabilises and per decedent starts to drop (Figure 2). The death rate is below 1% for most of the life-span and starts to exceed 10% above the age of 82 for men and 89 for women. Therefore it seems that the stabilisation of the costs per survivor under the age of 70 cannot be explained by the mortality rate. Life expectancy at the age of 70 exceeds 12 years for men and 15 for women (data taken from the Central Statistical Office of Poland). This stability takes place without an important rise in users and mostly occurs in inpatient care and the refunding of drugs (Figure 4c, 4d). The decrease in expenditure per decedent thereafter is either an effect of implicit social choice or the morbidity pattern, which cannot be further checked using our data.

Death-related costs are deemed age-dependent if they result in the health expenditure being age dependent. The main growth of HCE takes place from 35 to 70 years of age at an increasing pace. Only one fourth can be attributed to rising death rates with the rest resulting from the rising costs of treatment per survivor. After the age of 70, spending stops rising and becomes less age-dependent, while the rising death rate dominates the dynamics of HCE per capita. We also show that the size of the cohorts plays an important role in shaping HCE. Finally, we hereby underline that the consequences of age-dependent and proximity-to-death assumptions differ vastly in terms of the reaction of HCE to ageing.

I have shown the significant differences in health costs generated by survivors and decedents. These differences are, however, not large enough to enable us to exclude age from the determinants of HCE. Firstly, death-related costs are deemed to be age dependent if they result in age dependency of health expenditure. The main growth in HCE takes place from 35 to 70 years of age at an increasing pace. Only one fourth can be attributed to rising death rates with the rest resulting from the rising costs of treatment per survivor. After the age of 70, spending stops rising and becomes less age-dependent, while the rising death rate dominates the dynamics of HCE per capita. We also show that the size of cohorts plays an important role in shaping HCE. Finally, we hereby underline, that the consequences of age-dependent and proximity-to-death assumptions differ vastly in terms of the reaction of HCE to ageing.

Most previous results in favour of the hypothesis about the independence of HCE and age, called the *red herring* hypothesis, are driven by inpatient care. Our analysis confirms that hospital costs depend to a great extent on the proximity to death, but that the incidence of using hospital care is strongly age-driven. Long-term care and hospice costs are very death-related, whereas outpatient care and drug refunding depend mainly on age. All in all, age remains the main driver of health care costs either due to the rising incidence of care or based on the expenditure per patient. To the best of our knowledge, this is the first work about the role of age and the proximity to death from a Central and Eastern European country with fast-ageing population, that utilises population-wide data about various types of care.

6 Conclusions

The costs incurred by decedents are significantly higher than for survivors, whereby the difference becomes smaller with age. The decedent ratio is not the main driver of health care costs which rise with age. If the costs incurred just one year before death are included, the health care costs remain strongly dependent on age. The rise of health care costs with age is mainly driven by the intensity of care per survivor. Rising mortality with age leads to two opposite phenomenon in terms of health care expenditure. The rising ratio of decedents leads to an increase in costs, whereas the drop in population size due to death reduces these costs significantly. The effect of the latter outweighs the effect of the former. In other words, a drop in mortality accompanied by unchanged morbidity would sharply increase health care costs. In the case of hospital costs, which constitute the biggest share of health care expenditure, the role of the rise in the decedent ratio is more important and almost outweighs the population change due to death.

A new method has been applied to the analysis of aggregated data about health care expenditure. In order to carry out a robustness check, more precise data is needed. In particular, data about expenditure 2-5 years before death would enable the crucial assumptions on the stability of the functional form of cost acceleration before death to be tested. They are, however, unavailable in Poland to date. The careful analysis of morbidity and the costs of treatment also remain an open field for research.

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