

What drives Healthcare Expenditures - Mortality in general or High Cost-risk Patients and their Mortality? A Distributional Analysis of Germany's Social Health Insurance

Valeska Hofbauer-Milan

WHU – Otto Beisheim
School of Management /
AOK Baden-Württemberg

valeska.hofbauer-
milan@whu.edu

Stefan Fetzer

Hochschule Aalen

stefan.fetzer@hs-
aalen.de

Christian Hagist

WHU – Otto Beisheim
School of Management

christian.hagist@whu.edu

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**Valeska Hofbauer-Milan*, Stefan Fetzer,
Christian Hagist**

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Abstract

Background: In view of steadily rising healthcare expenditures (HCE), studies on spending distributions can provide important guidance for policy decisions. Since the majority of HCE is concentrated in a few high-cost cases, this study focusses on the spending distribution between different cost-risk groups. We show detailed allocation structures, distinguishing several categories of HCE and the survival status of insureds to gain insights regarding the share of mortality costs.

Methods: Our analyses rely on data from a large sickness fund that covers around four million insureds. We classify the population into ten equal risk groups by costs and then determine expenditure shares of total HCE and daily per-capita expenditures depending on survival status and risk group affiliation.

Results: Our results offer that the often stated dominating effect of mortality costs of HCE is only evident in lower cost-risk groups and almost exclusively attributable to inpatient care. Furthermore, HCE in the calendar year of death is the same for most cost-risk groups, with the exception of risk groups at both ends of the distribution. However, in the case of the highest cost-risk group, the difference between survivors and decedents is proportionally small. The differences in cost structure between decedents in high-risk and other risk groups are primarily attributable to pharmaceutical spending.

Conclusion: Short-term high HCE in the year of death occur equally in all cost-risk groups and are hardly avoidable. By contrast, in the extremely high cost-risk groups, the cost difference between the year before death and the year of death is much smaller. Overall, this group remains the main target to influence the rise in HCE and its characteristics should be considered with respect to future HCE projections

Keywords: social health insurance; health expenditure distribution; cost risk groups; cost of dying; risk-group specific mortality

* Correspondence: valeska.hofbauer-milan@whu.edu.

1. Introduction

Steadily increasing (real) healthcare expenditures (HCE) have been a phenomenon observed for decades in many OECD countries [1]. Possible causes for the increase in HCE are medical innovations, growth of real income, regulations such as pricing policies for medical products, and the ageing of the population [2]. The latter is one of the most controversial topics in health economics. Indeed, there are fears that the changing demographic structure, with fewer and fewer working people facing a growing number of retirees incurring higher HCE at older ages, will jeopardize the fiscal sustainability of healthcare systems in OECD countries such as Germany [1,3]. However, about two decades ago, Zweifel et al. (1999) identified the demographic effect of higher HCE in older age groups as a possible "red herring" and pinpointed mortality costs as the decisive determinant of high HCE [4]. Accordingly, a longer life expectancy, one of the two drivers of ageing societies next to low fertility, would merely shift high spending in the last year(s) of life to a later age [4-8].

In addition to the growth of HCE, an increasing concentration of HCE has been observed in a small risk group of high-cost patients in many developed countries, such as Germany [9-12]. The German health care system can be divided into two parts. The first, smaller part comprises about 10 percent of the population with full private health insurance coverage, which is partially subsidized by the state for civil servants (cited here by Bühner et. al. 2018 [13]). The second, larger part comprises 90 percent of residents in Germany who are covered by statutory health insurance (SHI). Within this, there are currently 96 health insurance funds, among which the insured are largely free to choose [14, 15]. In order to balance the financial consequences of unequal distribution of spending risks, such as age, sex, place of residence and disease burden (morbidity) between the health insurance funds, there is a risk structure compensation scheme [15]. In this, the expenditures of the SHI are structured according to certain variables such as cost categories, age, and gender.

Analyses of SHI costs show that the most expensive ten percent of insureds account for 60 percent of total HCE [11]. But 20 percent of public total HCE are responsible solely to the group of the most expensive one percent, again with an increasing trend [11,12].

Taking an actuarial perspective, insureds are usually divided into risk groups based on different socio-demographic factors to quantify their risk of incurring high expenses [16]. However, if proximity to death is a key factor in high spending, it should also play an important role in an

insured's individual cost risk. Thus, the question arises of how far mortality costs are related to high-cost cases (and vice versa). Several studies examined the characteristics and spending profiles of high-cost cases in Germany in detail [9,11,12]. They are also repeatedly discussed regarding possible risk selection in the German SHI and legal structures to avoid it [17-19]. However, to date, we are not aware of any study that has examined the costs of dying in different cost-risk groups for Germany.

Our article aims to fill this research gap. Based on data from a large German sickness fund covering around four million insureds from 2011 to 2019, we first divide the entire study population into ten risk groups by costs of equal size, followed by a detailed examination of their expenditures in various categories of HCE, particularly depending on survival or death. This allows us to show which type of expenditures dominate in the several cost-risk groups and to what extent they are attributable to mortality costs.

The paper is organized as follows: We first describe our methods of analysis and then present the results on the distribution and structure of HCE in the different cost-risk groups differentiated by survivors and deceased. This is followed by a detailed discussion of the results in the context of other studies, also considering our approach's limitations. Finally, we conclude the paper with policy implications and our conclusion.

2. Methods

Our analyses rely on a comprehensive data set from a large statutory sickness fund, the Baden-Württemberg AOK, that spans the periods from January 2010 to December 2019. The data set includes socio-economic characteristics such as age, sex, duration of insurance, and date of death. In addition, it contains all related expenditures eligible for the risk structure compensation scheme according to §4 of the "Risikostruktur-Ausgleichsverordnung" (RSAV) [20], representing around 95 percent of total SHI-covered HCE. The expenditures are already cumulated by the respective seven main categories: expenses for outpatient care, dental care, inpatient care, sick pay, pharmaceuticals, dialysis, and other expenses. "Other expenses" include, for example, expenses for remedies, aids, patient transport, or rehabilitation. For details on eligible services and allocations to the main service areas, see the Federal Office of Social Security databases [21].

The study population used for the analysis contains only individuals with a full insurance period of at least 360 days in all years 2011 to 2019 unless they were born or died in one of

the analysis years. The insurance period after birth or before death must also be complete in the latter two cases. After applying the inclusion criteria mentioned above, approximately three million insured individuals remain as the study population. For each calendar year, we first divide the study population into survivors and decedents. All survivors with at least 360 days of insurance are then classified into ten risk groups by costs, based on their share of total healthcare spending in the service areas listed above. To eliminate the classification bias of the risk group due to incomplete insurance years and costs after birth, we excluded the cohort of zero-year-olds for each calendar year.

The cost-risk groups consist of deciles, starting with risk group one as the most expensive ten percent of insureds in descending order to the least expensive ten percent. To account for the extreme concentration of costs among a few high-risk insureds, for some analyses, the top ten percent are again subdivided into cost-risk group 1a as the most expensive one percent, cost-risk group 1b as the second most expensive four percent, and cost-risk group 1c as the third most expensive five percent.

Table 1: Cost-risk group classification of the study population 2018.

Cost-risk group	Number of insured	Population share	Share of HCE 2018	Average Age	Share of women	Share of men	
1	1a	28,478	1%	20,4%	63,0	46,2%	53,8%
	1b	113,909	4%	26,3%	64,9	54,4%	45,6%
	1c	142,386	5%	15,5%	64,5	58,8%	41,2%
2	284,773	10%	15,3%	60,5	58,9%	41,1%	
3	284,769	10%	8,0%	57,7	57,8%	42,2%	
4	284,776	10%	5,0%	53,4	58,5%	41,5%	
5	284,769	10%	3,4%	49,6	58,3%	41,7%	
6	284,776	10%	2,4%	46,1	57,7%	42,3%	
7	284,768	10%	1,7%	40,3	55,4%	44,6%	
8	284,775	10%	1,2%	34,8	52,5%	47,5%	
9	284,768	10%	0,7%	33,2	46,6%	53,4%	
10	284,779	10%	0,2%	41,5	35,9%	64,1%	
Total survivors	2,847,726	100%	100 %				
Survivors	2.847.726	98%	92%	48,0	53,8%	46,2%	
Deceased	49,012	2%	8%	80,5	54,5%	45,5%	
Total population	2,896,738	100%	100%	48,5	53,8%	46,2%	

Source: Own depiction.

For a further detailed analysis of the cost distribution in our study population, we use the following procedure: First, we divide the study population into survivors and deceased. All survivors are then assigned to cost-risk groups based on their annual HCE. The distribution of HCE, comparable with the results of other studies on HCE distribution for Germany [11, 12], as well as the age- and sex-specific characteristics of the cost-risk groups are shown in Table 1 for 2018. Additionally, the table also includes a comparison of survivors and decedents.

In a second step, the cost-risk groups can be analyzed in detail with respect to the distribution of HCE. For this purpose, we use the size of daily per capita expenditures, since in a calendar-year-based view the time span of the deceased is less than 360 days. For survivors, we further distinguish between those who survive the next calendar year and those who die in the next calendar year, broken down by cost-risk groups.

In a third step, we examine the composition of HCEs by different cost categories. To make the results comparable with other studies on German SHI expenditures, the daily HCE per category of the study population are calibrated to the category expenditures in the entire German SHI according to the official annual statistics [22]. Therefore, we use the last comparable calendar year (2018) for the expenditure analyses.

Finally, we show the demographic characteristics of the different cost-risk groups affiliation probabilities and mortality rates by sex and individual age.

3. Results

We begin our analysis of the distribution of HCE with Table 2, which shows the average per-capita daily HCE in 2018 of survivors and decedents, initially without any risk group classification. We compare the daily spending of three groups:

Survivors, who survive at least the next full calendar year 2019, survivors who die in the following calendar year 2019 (decedents – calendar year before death) and persons who died in 2018 (decedents – calendar year of death).

This comparison clearly shows the effect of mortality costs. With an average per-capita daily HCE of only 8 €, the survivors have considerably lower expenses than the deceased in the year before and in the year of their death. In addition, the sharp increase in HCE with rising proximity to death becomes apparent, as the HCE of the deceased in the calendar year of death, at 83 €, is more than twice as high as the HCE of the deceased in the calendar year before death, at 36 €.

Table 2: Average daily HCE of survivors and decedents 2018

Group	Average daily HCE 2018
Survivors	8 €
Decedents – calendar year before death.	36 €
Decedents – calendar year of death	83 €

Source: own depiction.

In a next step, we want to take a closer look at daily per capita HCE within the different cost-risk groups, also differentiated according to the three groups presented in Table 2. The risk group classification of the first two groups (survivors and decedents – calendar year before death) is based on HCE in 2018. In contrast to this, a cost-risk classification of the persons who died in 2018 (decedents – calendar year of death) makes only sense on the basis of the year 2017, as a complete calendar year is always required for risk group classification.

Figure 1 shows that those who die in the current calendar year have the highest daily per-capita HCE in all risk groups. Thus, as might be expected, HCE are highest in the calendar year of death. However, remarkably, the daily spending in the calendar year of death is nearly the

same across all risk groups, with around 60 € per capita and day. Only the most and least expensive ten percent differ considerably. Daily per-capita spending of the most expensive one percent (cost-risk group 1a) reaches nearly 200 €. In contrast, the cheapest ten percent generate only 39 € in daily expenses in their calendar year of death.

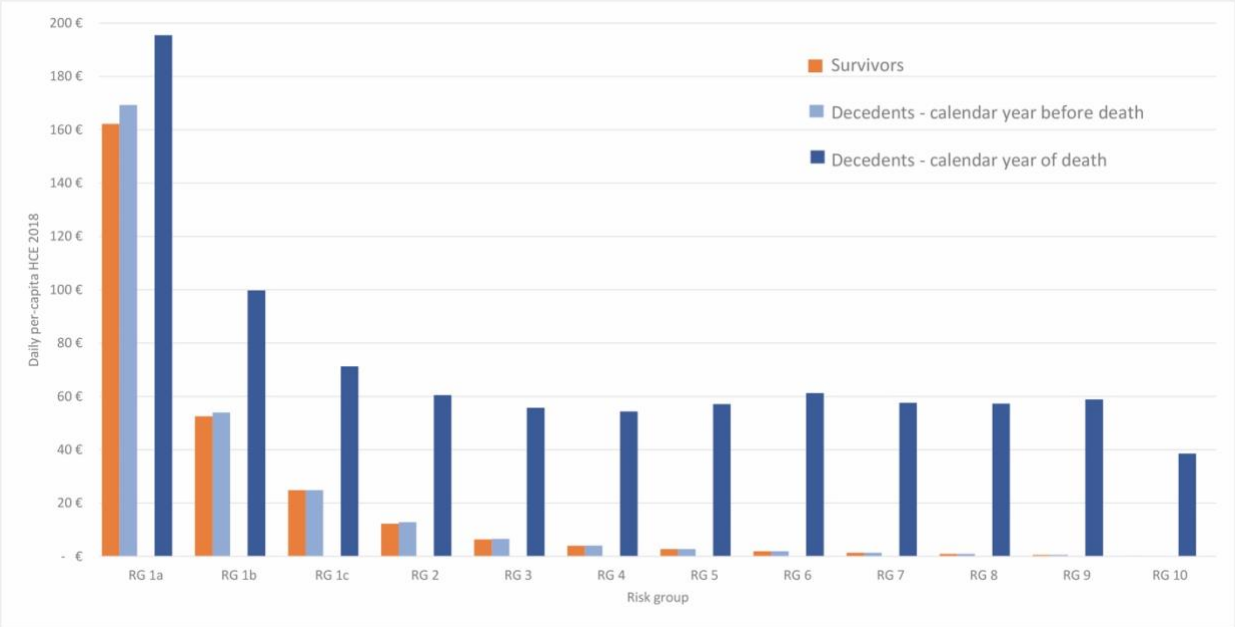


Figure 1: Daily per-capita HCE 2018. Source: Own depiction. RG = Risk group

Comparing now all three groups, we can see that the difference between the survivors, those who die in the next calendar year, and those who die in the current year is proportionally small for the most expensive one percent. Thus, the costs in the year of death do not appear to drive these insureds to become high-cost cases at first glance. Comparing the daily per-capita costs 2018 of those who die in the following and those who survive the following calendar year, we observe almost no difference between annual per-capita HCE, which applies to all cost-risk groups. Thus, mortality costs do not appear to reach a relevant level in the calendar year prior to death, but only in the year of death.

In a next step, we further break down our cost analysis into different cost categories. Table 3 shows the proportional distribution of total HCE between survivors and decedents in 2018 along with the related breakdown between categories. Taking this approach, we see that the deceased account for only eight percent of total HCE, with five percent attributable to cost-risk group 1. Therefore, the mortality costs of the vast majority of insureds play hardly any role in total HCE.

Table 3: HCE distribution between survivors and decedents 2018.

a. Survivors 2018								
Risk group affiliation 2018	Share of total expenditure 2018	Distribution among service areas						
		Outpatient care	Dental care	Inpatient care	Pharmaceuticals	Sick pay	Dialysis	Others
1	57%	7%	1%	43%	23%	9%	2%	15%
1a	19%	4%	0%	44%	30%	5%	4%	12%
1b	24%	7%	1%	44%	21%	12%	0%	14%
1c	14%	12%	3%	40%	17%	8%	0%	20%
2	14%	23%	8%	29%	19%	4%	0%	17%
3	7%	34%	15%	12%	23%	2%	0%	14%
4	5%	40%	23%	4%	22%	1%	0%	11%
5	3%	44%	27%	2%	18%	1%	0%	9%
6	2%	48%	27%	1%	16%	1%	0%	7%
7	2%	53%	25%	0%	15%	1%	0%	5%
8	1%	57%	26%	0%	13%	1%	0%	4%
9	1%	59%	28%	0%	10%	0%	0%	2%
10	0%	63%	29%	0%	7%	0%	0%	1%
Total	92%	17%	7%	33%	22%	6%	1%	14%

b. Decedents 2018								
Risk group affiliation 2017	Share of total expenditure 2018	Distribution among service areas						
		Outpatient care	Dental care	Inpatient care	Pharmaceuticals	Sick pay	Dialysis	Others
1	5%	4%	0%	59%	17%	1%	2%	16%
1a	2%	4%	0%	51%	23%	2%	4%	15%
1b	2%	5%	0%	62%	16%	1%	0%	16%
1c	2%	5%	0%	66%	11%	1%	0%	17%
2	1%	5%	1%	70%	10%	1%	0%	14%
3	1%	5%	1%	74%	8%	1%	0%	11%
4	0%	5%	0%	75%	8%	1%	0%	11%
5	0%	4%	1%	78%	6%	0%	0%	10%
6	0%	4%	0%	80%	5%	1%	0%	9%
7	0%	4%	0%	80%	5%	1%	0%	9%
8	0%	3%	0%	80%	6%	2%	0%	9%
9	0%	3%	0%	75%	8%	2%	0%	11%
10	0%	2%	0%	81%	5%	3%	0%	9%
Total	8%	5%	0%	65%	14%	1%	1%	14%

Source: own depiction.

Considering the distribution of deceased among categories by cost-risk group, it becomes clear that dying in a hospital causes the costs in the year of death. Hospital expenditures account for 70 to 80 percent of decedents' expenditures, except in cost-risk group 1. Their hospital expenditures already account for around 40 percent among survivors, but then increase only slightly in the case of death. With an expenditure share of 30 percent, pharmaceutical spending plays a significant role in the most expensive one percent (cost-risk group 1a) together with costs for dialysis, which occur only among the most expensive 1 percent regardless of survival status. In the lower risk groups of survivors, spending on outpatient care accounts for the majority of HCE, as well as on dental care and, to a lesser extent, pharmaceuticals.

All in all, our analysis so far indicates that proximity to death is probably not the main factor explaining HCE when controlling for different cost risks. However, as age can be a factor in itself that determines the cost risk and the level of related mortality costs, it might be interesting if

the different risk groups vary in demographic characteristics. Figure 2 shows the cost-risk groups' age- and gender-specific affiliation probabilities (primary axis) and mortality rates (secondary axis). They are computed as averages of all available analysis years 2012 to 2018, as only small numbers of cases are available in some age groups. Due to the relatively small cohort sizes for very old cohorts, we calculated rates in groups of five for those over 95 years of age.



Figure 2: Average affiliation probabilities and mortality rates in the different cost-risk groups by age.
 Source: Own depiction.

The primary y-axis shows the affiliation probabilities, and the secondary y-axis shows the mortality rates. Age is plotted on the x-axis, and we make an additional distinction between the sexes.

The upper left part of Figure 2 shows that the probability of belonging to risk group 1 increases significantly with age, reaching a maximum of 14 percent at about age 87 for both men and women. The trend of an increasing affiliation probability with age can also be observed in risk groups 2 to 3. From risk group 4, the affiliation probability curves flatten, while in risk groups 5 to 10, the younger cohorts have the highest affiliation probability.

In summary, there is a strong correlation between affiliation probability and high age in the high cost-risk groups 1-3. The reverse effect can be observed in the low cost-risk groups 7-10. The slight outliers in every cost-risk group can be explained by age- and gender-specific factors, for example, by maternity or expenditure on contraceptives. Also noticeable is that middle-aged women are more likely to belong to a more expensive risk group.

The mortality rates of low-cost risk groups 5 to 10 are relatively low. Increased mortality does not occur until risk group 3. Thus, 85-year-olds in risk group 1 are more than three times as likely to die as 85-year-olds in risk group 10. In risk group 1, mortality in the younger age groups is also significantly higher than in the other risk groups. Therefore, a higher cost risk is also associated with significantly higher mortality. This is also the reason that can explain the slightly contradictory results of Table 2 (a high difference between the daily costs of survivors versus those who die in the next year) and Figure 1 (the differences almost disappear between the groups): A high risk group is associated with a higher average age and a higher probability of dying (in the next year). Conversely, the group of those who die in the next year consists to a disproportionate extent of higher risk groups (if the risk group is not controlled).

4. Discussion

Our results extend the literature, as we show the relationship between cost-risk groups and the costs in the year of dying (and the year before). By looking at both daily spending and the proportional distribution of spending in relation to the total population, we can provide a comprehensive overview of the expenditure structure broken down by categories of spending. Although the results for the lower cost-risk groups (RG 2-10) are as expected, our results reveal three main (partly unexpected) characteristics of the high cost-risk groups (RG 1a, 1b, and 1c):

Firstly, high cost-risk is strongly correlated with age, as we have seen when looking at the affiliation probabilities. Secondly, as expected, the high cost-risk groups also have higher mortality rates by age group compared to the other risk groups. Third, and surprisingly, there is very little difference in spending between decedents and survivors in high-risk groups.

For the other risk groups, mortality costs occur only in the calendar year of death, and their amount is independent of the cost-risk group to which the patient belongs. In addition, the results confirm the expectation that mortality costs are primarily caused by hospitalizations. Pharmaceutical spending, with an increasing concentration in a few high-cost cases, and expenditures for dialysis are primarily responsible for the crucial difference in cost structure between the decedents in high cost-risk and other risk groups.

The results can be placed in the previous literature, where high cost-risk insureds are defined as the most expensive one and five percent. With 51.2 % hospital and 23.3% drug expenditures, Lange et al. (2020) can also identify these two categories as the main cost pools of high-risk patients [23]. Also in line with other national and international studies is the expected strong correlation between the probability of belonging to the most expensive cases and age, as well as a substantially increased mortality rate compared to the overall population [12, 23, 24]. The higher proportion of women in groups with higher cost risk (RG 1 and 2) is also consistent with the findings of other studies [12, 23, 25]. For a comprehensive review of the literature on other socio-demographic characteristics or frequently diagnosed diseases of high-risk insureds, see Wammes et al. (2018) [26].

Concerning the comparison between survivors and decedents, the work of Stahmeyer et al. (2012) presents a detailed analysis of the spending characteristics of decedents and survivors for Germany based on a similar data set from 2017 [27]. They also find a massive increase in pre-death inpatient care spending and a nine percent share of total HCE attributable to decedents. The slight difference from our result of eight percent is probably due to their consideration of the last year before the date of death rather than the calendar year of death as we do. By looking at spending each quarter before death, they determine that half of all healthcare spending in the last year of life is attributable to the previous quarter before death. This is consistent with our findings of a significant difference in spending between survivors and decedents only in the calendar year of death. Karlsson et al. (2016) also confirm this result based on data from a private German sickness fund. In their analysis, the difference in spending

between survivors and decedents decreases by half when looking back more than a year before death, suggesting pure mortality costs and a less age effect [9]. A recent comparison of survivors and decedents (in their last 4 years of life) with respect to spending growth rates according to different indications by Breyer et al. (2021) [28] further shows that spending growth is highly diagnosis dependent. While among the deceased, disproportionate spending growth can be observed for cancer treatment (especially malignant neoplasms), for the survivors, pregnancies and mental and behavioural disorders show stronger spending growth rates [28].

Bynum et al. (2017) find in their analysis for the U.S. that high-cost Medicare and Medicaid insureds can be divided into two distinct groups: Older beneficiaries facing the end of life and younger beneficiaries with ongoing functional support needs [29]. Aldridge and Kelley (2015) also take a closer look at the deceased within the high-cost cases for the United States. Although they find that most decedents are in the high-cost group, the majority of high-cost cases are still not in their last year of life [30]. Wammes et al. (2017) also show for the Netherlands that dying increases the risk of incurring high costs, but less than ten percent of beneficiaries with high costs are in their last year of life [24]. Davis et al. (2016) try to find cost drivers at the end of life of older Medicare beneficiaries [31]. Their findings suggest that HCE at the end of life is often an indicator of the general spending profile, beginning long before death, which is in line with our results for the group of the most expensive one percent.

In summary, the literature on the cost of dying indicates that high costs occur at the end of life, sometimes several years before death [32]. Our results support these findings, in that high cost-risk patients are much more likely to die, resulting in higher end-of-life costs when averaged across all risk groups. However, our contribution to the literature on the cost of dying is that the effect of higher end-of-life costs disappears when high cost-risk groups are considered alone. Since a very high proportion of total expenditures is accounted for by the group of high cost-risk patients, the following two factors are likely to be important for the future development of HCE: First, the development of the number of high cost-risk patients and, second, the increase in their life expectancy.

Of course, our results also have some limitations, firstly regarding the study population. As we examined a closed study population, which can be entered only by birth or exit by death, we could not include individuals who changed their sickness fund during this period. Furthermore,

the expenditures considered are also subject to some limitations. The classification of risk groups only allowed for an analysis of expenditures from full calendar years, which means that the period until the deceased's death is not always the same for every person. However, Karlsson et al. (2016) show in their analysis that there is no difference in the expenditure differential between decedents and survivors depending on whether to take an exact view of the year before death or the calendar year of death [9].

Finally, we can derive different policy recommendations from the relationship between individual cost risk and mortality costs. The first part relates to possibly avoidable expenditures or efficiency reserves in the area of mortality costs. Besides sudden or accidental deaths without any mortality costs being incurred at all, we see many cases of short-term illnesses treated mainly in the hospital until death, clearly showing up as a cost difference to survivors in the lower-risk groups in the year of death. These cases are hardly predictable and are also barely preventable. Taking into account also their small share in total HCE and the small timeframe until death, we do not see any potential to significantly influence HCE.

This is quite different in cases where a severe chronic illness turns the insureds into high-cost cases already sometime before death. Despite their high mortality rate, we see this risk group's huge proportion of total spending as the main target for policy reforms. On the one hand, better outpatient care and effective case management for these groups of patients could prevent complications and hospitalizations [23]. Additionally, policymakers should also focus on the high pharmaceutical expenditures that distinguish dying high-risk cases from those in other risk groups. In line with Wende and Schmitt (2012) as well as Hofbauer-Milan et al. (2022), we see a significant increase in drug spending concentration [11, 33], which could be counteracted by pricing policies for new therapies, especially regarding orphan drugs.

The second part of policy implications concerns the optimal design of risk adjustment schemes between sickness funds. In this, both the strong spending concentration on high-risk patients and the risk of mortality costs for other insureds must be considered. Obviously, this was not sufficiently ensured for Germany for both cases until 2020. A high-risk pool was therefore introduced by a new law at the beginning of 2021, which covers 80 percent of the expenditures for high-cost insureds with annual expenditures of more than 100,000 euros [34, 35]. In addition, the cost of dying is implicitly taken into account through a regional compensation scheme, which is also introduced in 2021 [36]. Before the reform, on average, only about 35

percent of decedents' expenses are covered by risk adjustment [37], depending on the age cohort ranging from 7.3 percent for under-5-year-olds to 57.8 percent for 94-year-olds [38]. Thus, in light of our findings, the new law indeed contains important advances, but its accuracy cannot yet be precisely determined and should therefore be closely monitored.

5. Conclusion

Our analysis shows that clear mortality costs are only evident in the lower-risk groups. The extremely high HCE of the high-risk groups appear already some time before and increase only slightly toward death compared to the other risk groups. Since the high-cost-risk groups also have the highest mortality rates, the causality question remains open: Are high cost-risk patients expensive because they are about to die in the following years, or is a high cost-risk, in general, associated with high mortality? However, the answer to this question may not be essential. Especially for projections of future HCE, considering the high-cost cases' characteristics, like expenditure shares and specific life expectancy, seems to be much more relevant than the mortality costs of both high-cost cases and the rest of the population.

References

1. OECD. Fiscal Sustainability of Health Systems: Bridging Health and Finance Perspectives. Paris: OECD Publishing; 2015.
2. Bodenheimer T. High and rising health care costs. Part 1: seeking an explanation. *Ann Intern Med* 2005; 142(10):847–54.
3. DeStatis. Bevölkerung im Wandel: Ergebnisse der 14. koordinierten Bevölkerungsvorausberechnung. Wiesbaden; 2019 [cited 2022 Aug 19]. Available from: https://www.destatis.de/DE/Themen/Querschnitt/DemografischerWandel/_inhalt.html;jsessionid=28B0C78CF8E6EE9C38EE1CF5FC95BABE.live711#sprg233552.
4. Zweifel P, Felder S, Meiers M. Ageing of population and health care expenditure: a red herring? *Health Econ* 1999; 8(6):485–96.
5. Zweifel P, Felder S, Werblow A. Population Ageing and Health Care Expenditure: New Evidence on the "Red Herring". *Geneva Pap Risk Insur Issues Pract* 2004; 29(4):652–66.
6. Howdon D, Rice N. Health care expenditures, age, proximity to death and morbidity: Implications for an ageing population. *J Health Econ* 2018; 57:60–74.
7. Felder S, Werblow A, Zweifel P. Do red herrings swim in circles? Controlling for the endogeneity of time to death. *J Health Econ* 2010; 29(2):205–12.
8. Fuchs VR. "Though much is taken": reflections on aging, health, and medical care. *The Milbank Memorial Fund Quarterly. Health and Society*. 1984; (62):143–66.
9. Karlsson M, Klein TJ, Ziebarth NR. Skewed, Persistent and High before Death: Medical Spending in Germany. *Fiscal Studies* 2016; 37(3-4):527–59.
10. French E, Kelly E. Medical Spending around the Developed World. *Fiscal Studies* 2016; 37(3-4):327–44.
11. Wende D, Schmitt N. Hochkostenpatienten und Auswirkung des Risikopools in der GKV. In: Repschläger et al. (Hg.) 2021 - Gesundheitswesen aktuell 2021. p. 126–47.
12. Tanke MAC, Feyman Y, Bernal-Delgado E, Deeny SR, Imanaka Y, Jeurissen P et al. A challenge to all. A primer on inter-country differences of high-need, high-cost patients. *PLoS ONE* 2019; 14(6):e0217353.
13. Bühner C, Fetzer S, Hagist C. Adverse selection in the German Health Insurance System – the case of civil servants. *Health Policy* 2020; 124(8): 888-894.
14. GKV Spitzenverband. Zahlen und Grafiken: Kennzahlen der gesetzlichen Krankenversicherung. [cited 2023 Jul 25]. Available from: https://www.gkv-spitzenverband.de/service/zahlen_und_grafiken/zahlen_und_grafiken.jsp.
15. Blümel M, Spranger A, Achstetter K, Maresso A, Busse R. Germany: Health System Review. *Health Systems in Transition, 2020*; 22(6): pp.i-273.
16. Crocker KJ, Snow A. The Theory of Risk Classification. In: Dionne G, editor. *Handbook of Insurance*. New York, NY: Springer New York; 2013. p. 281–313.
17. McGuire TG, Schillo S, van Kleef RC. Very high and low residual spenders in private health insurance markets: Germany, The Netherlands and the U.S. Marketplaces. *Eur J Health Econ* 2021; 22(1):35–50.
18. Schillo S, Lux G, Wasem J, Buchner F. High cost pool or high cost groups-How to handle high(est) cost cases in a risk adjustment mechanism? *Health Policy* 2016; 120(2):141–7.
19. Wasem J, Buchner F, Lux G, Schillo S. Health Plan Payment in Germany. In: *Risk Adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets*. Elsevier; 2018. p. 295–329.
20. Verordnung über das Verfahren zum Risikostrukturausgleich in der gesetzlichen Krankenversicherung (Risikostruktur-Ausgleichsverordnung): RSAV [cited 2022 Aug 9]. Available from: <http://www.gesetze-im-internet.de/rsav/>.
21. Federal Office for Social Security. Bestimmungen des GKV-Spitzenverbandes: Anlage 1.1 - Archiv [cited 2022 Aug 9]. Available from:

- <https://www.bundesamtsozialesicherung.de/de/themen/risikostrukturausgleich/datengrundlagen/archivbestimmungen-des-gkv-spitzenverbandes/-anlage-11/>.
22. Bundesgesundheitsministerium. Finanzergebnisse der GKV; 2022 [cited 2022 Aug 17]. Available from: <https://www.bundesgesundheitsministerium.de/themen/krankenversicherung/zahlen-und-fakten-zur-krankenversicherung/finanzergebnisse.html>.
 23. Lange L, Pimperl A, Schulte T, Groene O, Tanke M. Hochkostenversicherte in Deutschland: Leistungs- und Kostenprofile. *Z Evid Fortbild Qual Gesundhwes* 2020; 153-154:76–83.
 24. Wammes JJG, Tanke M, Jonkers W, Westert GP, van der Wees P, Jeurissen PP. Characteristics and healthcare utilisation patterns of high-cost beneficiaries in the Netherlands: a cross-sectional claims database study. *BMJ Open* 2017; 7(11):e017775.
 25. Joynt KE, Figueroa JF, Beaulieu N, Wild RC, Orav EJ, Jha AK. Segmenting high-cost Medicare patients into potentially actionable cohorts. *Healthc (Amst)* 2017; 5(1-2):62–7.
 26. Wammes JJG, van der Wees PJ, Tanke MAC, Westert GP, Jeurissen PPT. Systematic review of high-cost patients' characteristics and healthcare utilisation. *BMJ Open* 2018; 8(9):e023113.
 27. Stahmeyer JT, Hamp S, Zeidler J, Eberhard S. Gesundheitsausgaben und die Rolle des Alters: Eine detaillierte Analyse der Kosten von Überlebenden und Verstorbenen. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 2021.
 28. Breyer F, Lorenz N, Pruckner GJ, Schober T. Looking into the black box of "medical progress": Rising health expenditures by illness type and age; 2021. Working paper No. 2101 [cited 2022 Jan 11]. Available from: <http://hdl.handle.net/10419/231468>.
 29. Bynum JPW, Austin A, Carmichael D, Meara E. High-Cost Dual Eligibles' Service Use Demonstrates The Need For Supportive And Palliative Models Of Care. *Health Aff (Millwood)* 2017; 36(7):1309–17.
 30. Aldridge MD, Kelley AS. The Myth Regarding the High Cost of End-of-Life Care. *Am J Public Health* 2015; 105(12):2411–5.
 31. Davis MA, Nallamotheu BK, Banerjee M, Bynum JPW. Identification Of Four Unique Spending Patterns Among Older Adults In The Last Year Of Life Challenges Standard Assumptions. *Health Aff (Millwood)* 2016; 35(7):1316–23.
 32. Breyer F, Lorenz N. The "red herring" after 20 years: ageing and health care expenditures. *Eur J Health Econ* 2021; 22(5):661–7.
 33. Hofbauer-Milan V, Fetzner S, Hagist C. How to Predict Drug Expenditure: A Markov Model Approach with Risk Classes. *Pharmacoeconomics* 2023;41:561–572. <https://doi.org/10.1007/s40273-023-01240-3>
 34. Federal Office for Social Security. Weiterentwicklung des Risikostrukturausgleichs [cited 2022 Aug 9]. Available from: <https://www.bundesamtsozialesicherung.de/de/themen/risikostrukturausgleich/weiterentwicklung/>.
 35. Gesetz für einen fairen Kassenwettbewerb in der gesetzlichen Krankenversicherung: Fairer-Kassenwettbewerb-Gesetz - GKV-FKG); 2020. (vol 2020) [cited 2022 Aug 9]. Available from: https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBI&start=%2F%2F%2A%5B%40attr_id=%27bgbl120s0604.pdf%27%5D#__bgbl__%2F%2F%5B%40attr_id%3D%27bgbl120s0604.pdf%27%5D__1660050092113.
 36. Federal Office for Social Security. Erläuterungen zur Festlegung von Risikogruppen, Zuordnungsalgorithmus, Regressionsverfahren und Berechnungsverfahren für das RSA-Ausgleichsjahr 2021. Bonn; 2020 Sep 30.
 37. Federal Office for Social Security. Risikostrukturausgleich: Ergebnisse des Jahresausgleichs 2020; 2022 Jan 10 [cited 2022 Aug 10]. Available from: https://www.bundesamtsozialesicherung.de/fileadmin/redaktion/Risikostrukturausgleich/Info Dateien%20 und%20Auswertungen/20220111_JA2020_Anlage_3.pdf.

38. Drösler S, Hasford J, Kurth B-M, Schaefer M, Wasem J, Wille E. Evaluationsbericht zum Jahresausgleich 2009 im Risikostrukturausgleich; 2011 Jun 22 [cited 2022 Aug 10]. Available from: https://www.bundesamtsozialesicherung.de/fileadmin/redaktion/Risikostrukturausgleich/Wissenschaftlicher_Beirat/2021020Evaluationsbericht_zum_Jahresausgleich_2009.pdf.