ABHANDLUNG

The evolution of private medical expenses for civil servants in Germany

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Abstract In this study we analyse private medical insurance data with respect to civil servants in Germany. This data is applied to pricing purposes in the market and may therefore be deemed as useful. In particular, we discuss average health care expenditure per capita by age over time. Thereby, we analyse inpatient and outpatient benefits as well as hospital cash and dental insurance. In essence, we observe an effect that we call the rectangularisation of the cumulative health care expenditure curve. In line with this finding, we note that the modal age (at which total medical expenses for in force business are highest) has increased by 10 years of age over the last decade with respect to inpatient benefits. Moreover, we apply a linear regression model based on mortality rates as regressor. We use the Siegel test for comparing different expenditure profiles and judging goodness of fit. As a result, we find that steepening of private medical expenses by age over time is prevalent for three out of four benefit types in certain age bands. As for outpatient claims provided to male civil servants, medicalisation dominates the evolution of the average claim amount by attained age over time. On the other hand, compression is of relatively high importance for inpatient claims.

Keywords Health care expenditure · Population ageing · Compression · Medicalisation · Steepening

JEL-Code I13 · I15

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Die Entwicklung der Krankheitskosten für Beamte in Deutschland

Zusammenfassung Gegenstand dieser Studie sind aggregierte Daten der Privaten Krankenversicherung in Deutschland. Konkret untersuchen wir Zeitreihen von Kopfschäden nach Leistung, Geschlecht, Alter und Kalenderjahr. Insbesondere beobachten wir die sogenannte Quadratur der kumulativen Krankheitskosten im Verlauf des Lebens. Dabei zeigt sich, dass das modale Alter, indem die höchsten Krankenhauskosten für die Bevölkerung auftreten, im Verlauf der letzten Dekade um zehn Lebensjahr gestiegen ist. Außerdem modellieren wir die Krankheitskosten als Summe von Sterbekosten einerseits und Kosten zum Erhalt der Gesundheit andererseits. Mit Hilfe eines linearen Regressionsmodells und des Siegel-Tests zum Vergleich von Kopfschadenprofilen erhalten wir Einsichten in die Evolution der altersabhängigen Kopfschäden in der Zeit: Kopfschadenprofile wurden für gewisse Altersgruppen im Verlauf der Jahre nachweislich steiler. Außerdem entdecken wir einen dominierenden Medikalisierungseffekt im ambulanten Sektor und einen bedeutenden Kompressionseffekt im stationären Sektor.

1 Introduction

Population ageing is prevalent in many countries around the world, see Lutz et al. (2008) for instance. There are two main reasons for ageing of society: longevity on the one hand and low fertility rates on the other hand. Oeppen and Vaupel (2002) elucidated the effect of rising longevity in the world: record life expectancy has increased by about one year of life every four calendar years.

As a consequence, there are serious implications for social welfare systems including national health services. Then, as people reach higher ages medical expenses per capita tend to increase. Some researchers argue this observation is caused by wear and tear of the human body. Others outline that proximity to death is the main driver. It still remains debatable which influencing factor, attained age or remaining life span, dominates medical spending over a person's lifetime.

Fries (1980) established the so-called compression theory. The monetary version of this concept states that the bulk of medical expenses during the lifetime of a human being is due in the last years of life. In line with increasing longevity the majority of health care cost is shifted to higher ages. As such, the claims profile is stretched over a wider life span. Therefore, an ageing society does not necessarily imply increased spending for public health. The compression theory is consistent with the belief that in the future we may primarily enjoy a longer period of life in good health.

On the other hand, according to the monetary version of the medicalisation theory, Verbrugge (1984) stated that an ageing population implies increasing medical expenses for society. The reason being that higher attained ages imply greater morbidity. Hip replacements und cataracts, for instance, are common surgical procedures in German hospitals. These medical operations tend to be conducted for elderly people. Population ageing implies that higher age groups make up a larger share of the population. As a consequence, public spending for health care increases, too.

Zweifel et al. (1999) argued that the cost of dying is central to the understanding as to why total health care expenditure rises with age. The authors found out that health care expenditure per capita was much higher in the last quarter of life than in the preceding seven quarters. They concluded that proximity to death is the main driver for the rise of health care expenditure per capita by age. Then, at higher ages there are plenty of people who are close to death. Consequently, health care expenditure for the elderly is higher than for younger people. Taking increasing longevity into account the bulk of a person's medical expenses is increasingly deferred to a later point in life. Hence, the curve of total health care expenditure per capita by age thus becomes flatter over time.

Seshamani and Gray (2004) replicated the above mentioned study. They concluded that both attained age and proximity to death explain the increase of health care expenditure per capita over time. In a subsequent study Zweifel et al. (2004) highlighted that attained age is significant for all those people who did not die soon afterwards. Wong et al. (2010) confirmed that both factors determine health care expenditure per head. According to these studies, proximity to death is the dominant factor in determining health care expenditure per capita by age over time.

In fact, medical spending aimed at preserving good health is deemed effective with respect to increasing longevity, see Becker et al. (2005) for instance. Ignoring this effect leads to overestimating the effect of proximity to death on total health care expenditure. Salas and Raftery (2001) pointed to the potential endogeneity of closeness to death. Felder et al. (2010) analysed endogeneity as a part of an empirical study. They concluded that the increase of health care expenditure is primarily caused by medical advances rather than population ageing.

Stearns and Norton (2004) pointed out that closeness to death is negatively correlated with both attained age and health care expenditure per capita. Yang et al. (2003) showed that time to death is the main reason for increasing inpatient care expenditures. Population ageing on the other hand causes long term care expenditure to increase. Notably, French et al. (2017) found out that medical spending in the last twelve months of life accounted for 8.5–11.2% of overall medical spending in different countries. All of this research shows that proximity to death must be considered when projecting total health care expenditure. Breyer and Felder (2006) calculated that per capita health expenditures of social health insurance would be overestimated when the cost of dying is ignored.

Getzen (1992) showed that total healthcare expenditure is correlated with gross domestic product. He deduced that the increase of health care expenditure over time may be mitigated by budget restrictions. Brockmann (2002) found out that the cost of dying decreases for the oldest old. This finding may indicate age related rationing. Busse et al. (2002) arrived at a similar finding when analysing days spent in hospital by age. Likewise, Niehaus (2006) showed that that the cost of dying is significant and decreases with age for the oldest. However, considering a fixed age band the cost of dying has increased over time due to medical inflation. Moreover, Niehaus disclosed that both, attained age and proximity to death, are significant drivers for health expenditure per capita. He concluded that medical inflation is the dominant cost driver.

In this paper, we analyse average medical claim amounts per capita by age over time. The subject of our research are civil servants in Germany from 2000 to 2019. In particular, we analyse inpatient and outpatient benefits as well as hospital cash cover and dental insurance. Our aim is to explore how average claims cost profiles changed over time. This research gives us some insights into the driving factors of the evolution of medical expenses by age over time.

To begin with, we discuss the secondary statistics of private medical data available to us. In the following section, we analyse average medical amounts per capita by age over time. Thereby, we distinguish between different benefits types. In Sect. 4 we compute total health care expenditure by age over time. In addition, we calculate cumulative distributions. In Sect. 5 we apply a linear regression model. It allows us to evaluate steepness and steepening of average medical claim amounts per capita over age bands rather than locally for specific ages. Finally, in Sect. 6, we decompose the evolution of private medical expenses per capita over time into two effects: compression and medicalisation.

2 Data

The German authority for financial supervision regularly publishes detailed statistics on private medical insurance business (BaFin 2021). This data is collected on a yearly basis from all insurance companies that are active in the German private health care market. In particular, BaFin provides figures on average medical claim amounts per capita by age, gender and benefit type for each calendar year. The data is presented in as so-called probability tables. In addition, there are mortality tables relating to the privately insured population as well as numbers of insureds exposed to risk.

It is worth highlighting that we analyse secondary data only. There may be changes over time in the way data was collected or summarised that are unkown to us since BaFin does not provide comprehensive documentation on this matter. In particular, the data comprises input from all insurance companies in the market. If some of these insurers or major players alter their data collection procedure the resulting effects might not be revealed to BaFin.

Notably, we do not adjust claim amounts as provided by BaFin for inflation. The reason being that we want to analyse the drivers of cost changes over time. We focus on data for insurance cover provided to civil servants as this is the main business for private medical insurance companies in Germany. In general, civil servants are not covered by the national health service—so-called sickness funds that are compulsory for most of the population. The state directly provides certain payments in case of sickness to its civil servants. The remainder of typically around 30–50% usually

Table 1 Number of male civil servants exposed to risk in private medical insurance

Year	Inpatient	Outpatient	Hospital cash	Dental
2009	1,216,573	1,449,275	1,272,645	1,415,236
2014	1,210,576	1,622,979	1,361,462	1,622,979
2019	1,163,465	1,670,315	1,428,415	1,670,103

Table 2 Number of female civil servants exposed to risk in private medical insurance

Year	Inpatient	Outpatient	Hospital cash	Dental
2009	1,255,617	1,504,019	390,619	1,467,608
2014	1,281,754	1,730,370	427,598	1,730,370
2019	1,254,656	1,837,203	503,069	1,837,924

is covered by private medical insurance. Attention is given to inpatient benefits, outpatient benefits, hospital cash and dental insurance. Tables 1 and 2 highlight the number of persons exposed to risk within the aggregated market data.

As for the age profile of the in force business, we compare vital statistics in Germany with male and female civil servants who are private medically insured with respect to outpatient benefits. Figure 1 shows the distributions by age and sex applicable to calendar year 2014. Within our insured population, younger ages are underrepresented. On the other hand, the share of older ages is higher than in the general population of Germany.
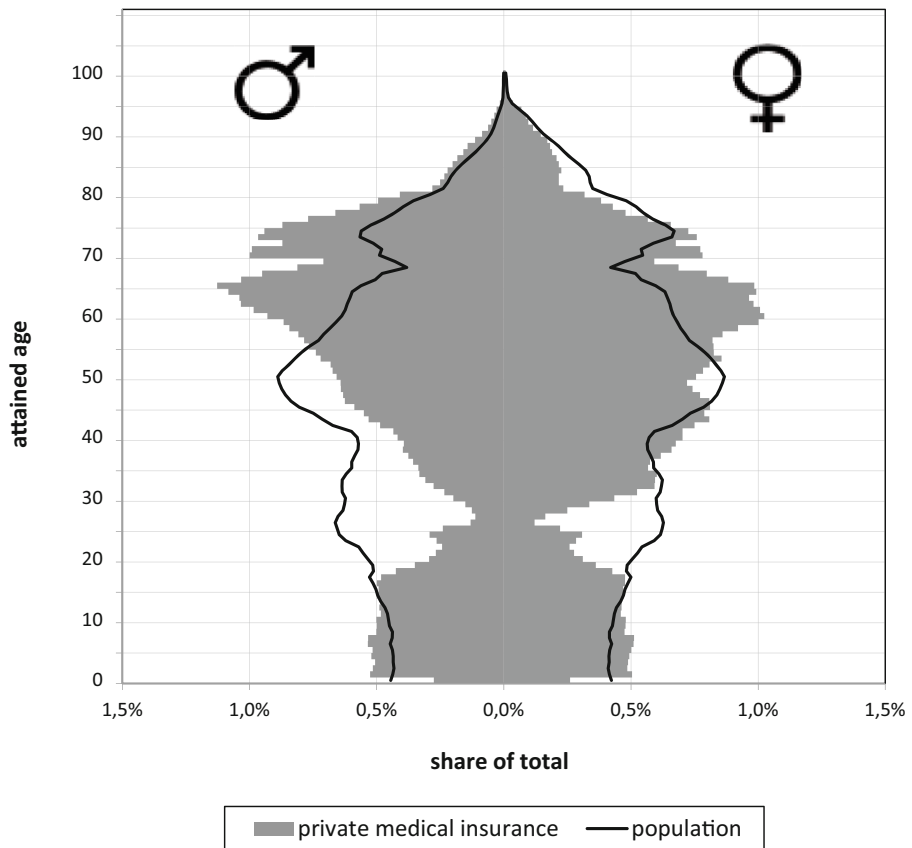
Fig. 1 Age distribution of exposed to risk relating to inpatient cover

3 Medical cost profiles over time

BaFin (2021) provides data on average claim amounts per head by age, benefit type
and calendar year. We define $h_t(x)$ as the average claim amount per head during
calendar year t for people aged x. Furthermore, we analyse relative changes in
subsequent years: $h_{t+1}(x)/h_t(x) - 1$. For outpatient benefits over the period from
2000 to 2019 the average annual rate of increase has been above 2.5% per annum
for all age groups (see Fig. 2).

Moreover, we visualise average claims cost profiles $h_t(x)$ by age x for certain
calendar years t. Thereby, we plot the average claim amount per head on the vertical
axis versus attained age on the horizontal axis. By so doing, we observe the change
in claims profiles over time.

As for outpatient benefits, average claims amounts have significantly increased
over time for all ages. In parts, this finding may be due to the fact that certain
medical procedures have been more and more outsourced from hospitals into day
clinics. Another reason for the year-to-year increase might be (medical) inflation.

Albeit not reported here in more detail, we would like to highlight a few more
findings on the data: The age profiles for inpatient benefits have also increased over
time albeit at a lower rate. We do not see a clear trend for the number of days spent in
hospital over time. Note that there is a grace period of up to six weeks before hospital
cash cover kicks in. The reason being that the state initially provides for ill people
by continuing to pay salaries to its civil servants. As for people aged 60+, however,
we note a pronounced increase in the number of days spent in hospital. Average
claim amounts for dental cover have increased sharply between 1999 and 2019, in
particular for older people. However, as for most ages we have more recently seen
a slight decrease. This observation may be due to better dental hygiene that comes
with a more widespread use of an electric toothbrush.

Figures 3 and 4 illustrate average claim amount profiles by age over time for
different benefit types with respect to male insureds.

As for female insureds, we observe some peculiarities. With respect to inpatient
benefits in 2019 we see a significantly different profile of average claim amounts
compared to previous years. There is a hump for younger females suggesting that
pregnancy benefits may be part of the reason that the profile is different from previous
years when pregnancy benefits may have been reported separately. Hospital cash

Fig. 2 Annual change of average claim amounts by age group over the period from 2000–2019 for outpatient benefits with respect to males
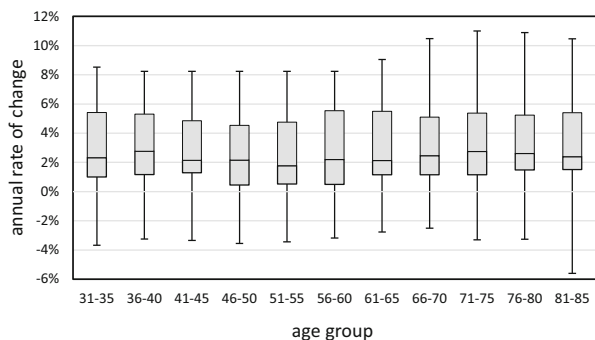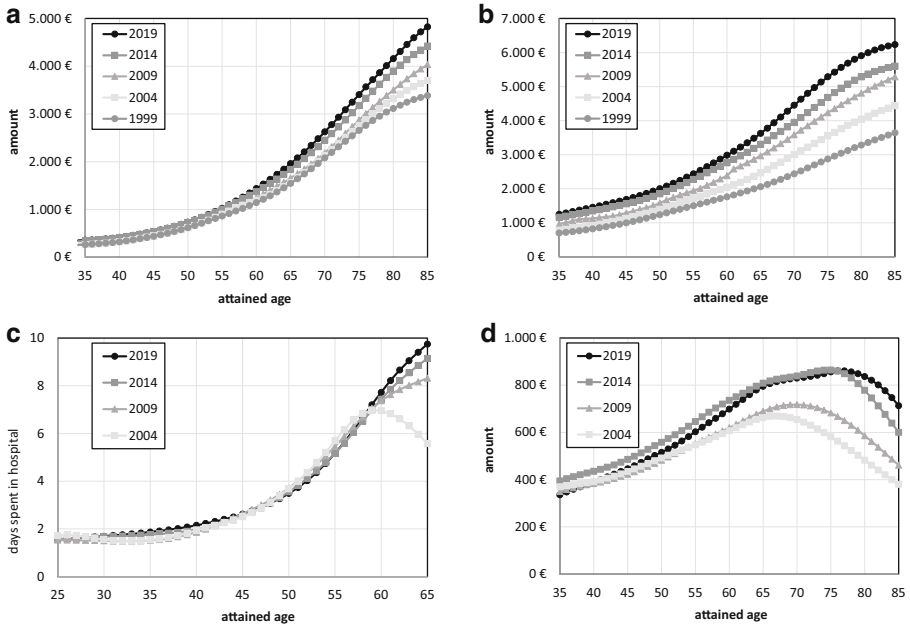
Fig. 3 Average claim amounts by age over time for different benefit types for male insureds
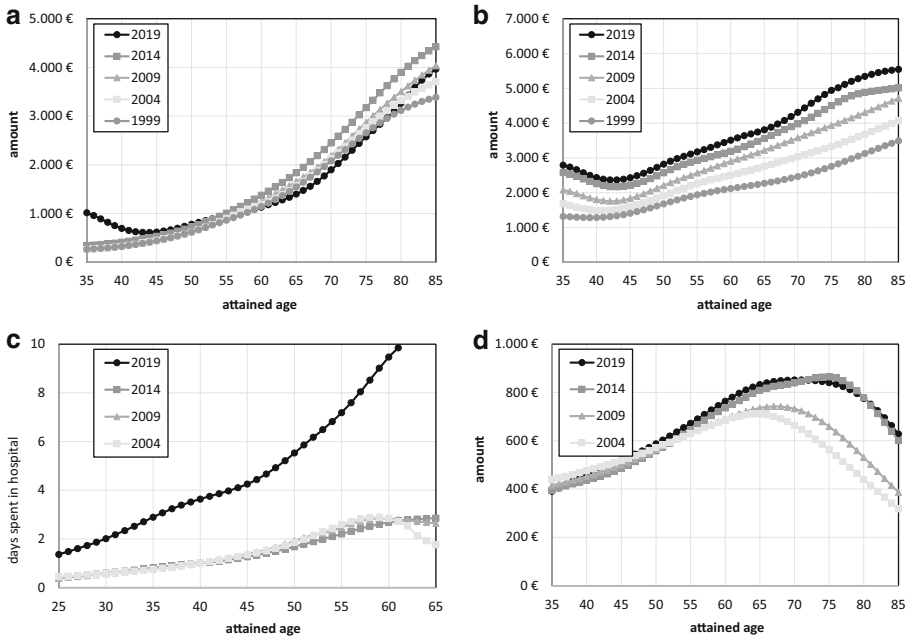
Fig. 4 Average claim amounts by age over time for different benefit types for female insureds

average claim amounts in 2019 are in line with those for males. Previous years in comparison seem to be too low. As we neither can fully explain nor correct these oddities within the secondary data set we primarily focus in the following on male insureds.

4 Total health care expenditure over time

The private medical insurance data provided by BaFin (2021) allows for computing total claim amounts by gender, age, benefit type and calendar year. To do so, we multiply the number of exposed to risk $l_x(t)$ at age x during calendar year t with the average claim amount per capita $h_t(x)$ in that year. Consequently, we derive total health care expenditure $e(x,t)$:

$$e(x,t) = l_x(t) \cdot h_t(x)$$

As a result, we observe that the maximum of $e(x,t)$ as a function of age for a given calendar year t has shifted to a higher age over time. To be specific, in 2009 approximately 50.8 million Euro were spent on inpatient claims for male civil servants aged 69. In 2019, the maximum was 82.5 million Euro for 79 year olds.

We define the modal age of health care expenditure $M(t)$ in calendar year t as the age where expenditure is highest:

$$M(t) = \{x_0 : e(x_0, t) \geq e(x, t) \; \forall x = 0, \cdots, 100\}$$

To sum up, the modal age of health care expenditure with respect to inpatient benefits has increased from age 69 in 2009 to age 79 in 2019 (see Fig. 5). This finding is in line with observations regarding the modal age at death that has also
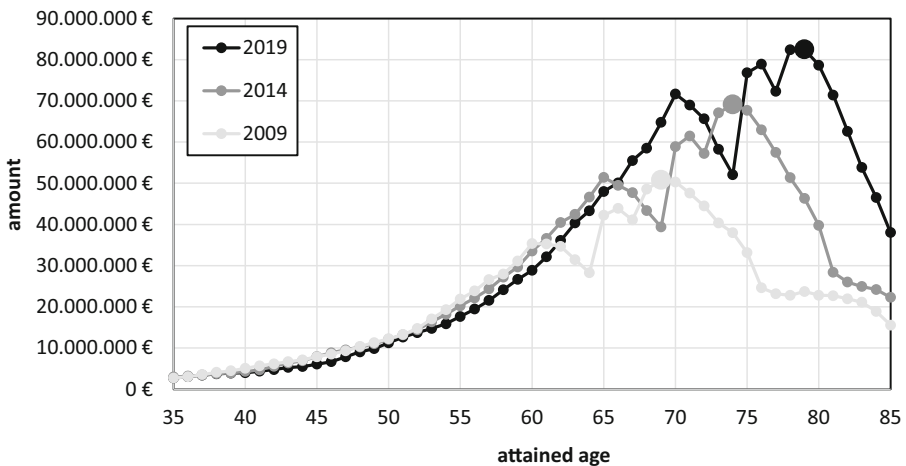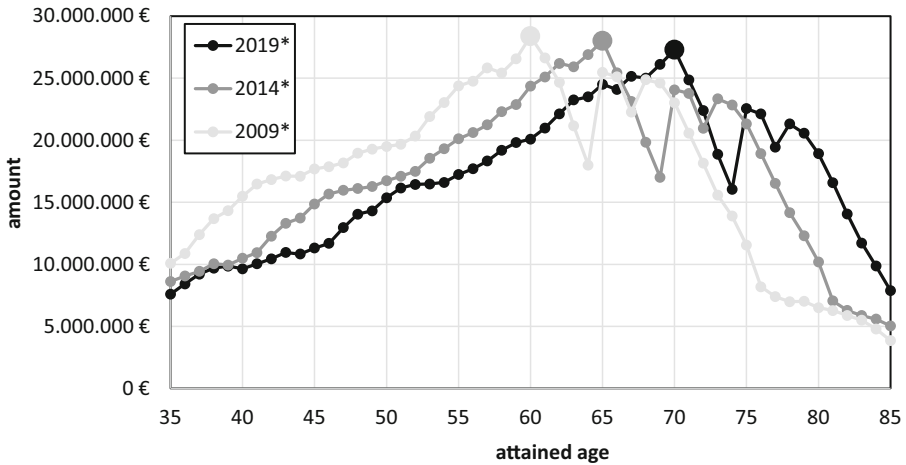

Fig. 5 Total health care expenditure with respect to inpatient benefits for male civil servants

Fig. 6 Hypothetical total health care expenditure for male insureds relating to inpatient benefits assuming a constant claim amount of 1000 € per capita

increased over time, see Kannisto (2001), Robine (2001) and Canudas-Romo (2010), for instance.

In conclusion, the evolution of total health care expenditure by age over time may be characterised in two ways. Over time, the maximum has shifted to the right and also upwards.

In order to identify the drivers of this development, we consider a constant average claim amount of 1000 € per head. It does not matter what amount we choose. Our findings hold likewise true for any other amount.

In essence, we assume that attained age has no impact on frequency and severity of medical claims. We then apply the constant claim profile to the number of exposed to risk for each calendar year, i.e., we set $\widetilde{e}(x,t) = l_x(t) \cdot 1000$. Fig. 6 elucidates the hypothetical total health care expenditure if we apply a constant average claim amount per head.
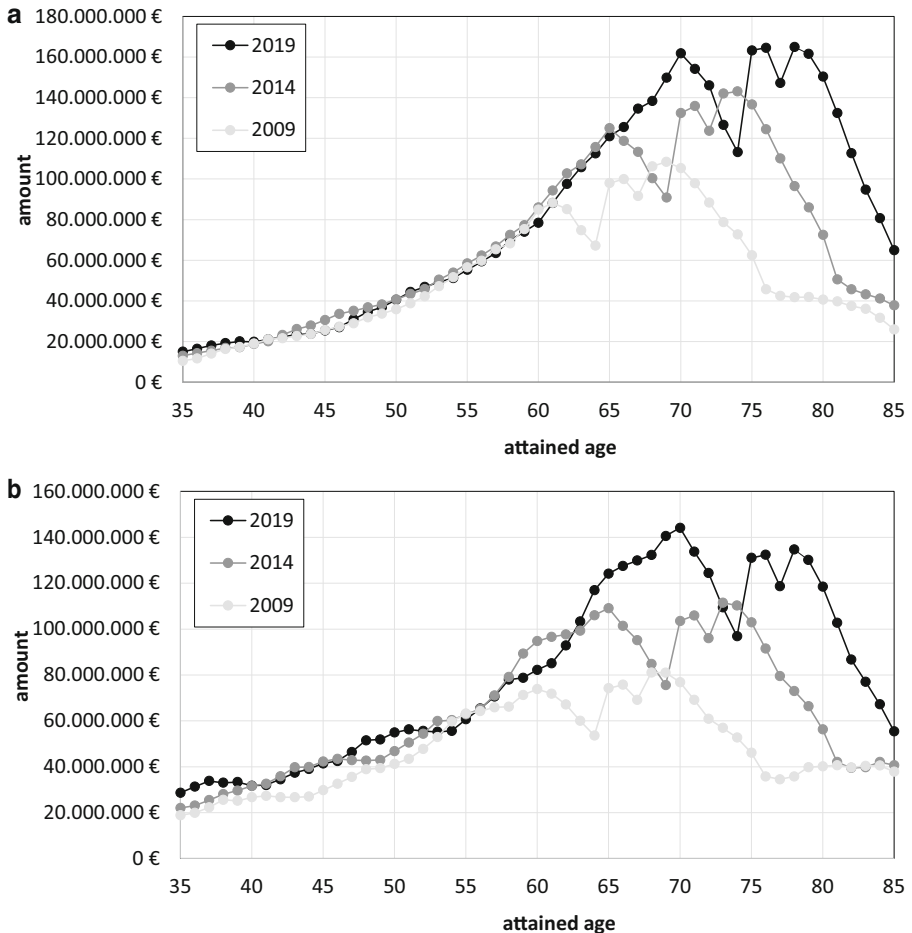
As for to expenditure with respect to inpatient benefits, the mode shifted 10 years of age during the last decade: from age 60 to age 70. Therefore, we have identified ageing of the in force business as the main driver for increasing the modal age of health care expenditure. Then the average claim amount is constant over age in this hypothetical modelling approach. On the other hand, the actual claims cost profile by age is responsible for shifting the maximum upwards.

As for outpatient benefits for male and female insureds alike the shift of the total expenditure curve is still visible but the change in the modal age is not as pronounced as can be seen in Fig. 7.

Finally, we define cumulative health care expenditure as

$$E(z,t) = \sum_{x \leq z} e(x,t)$$

and plot it against time in Fig. 8.

Fig. 7 Total health care expenditure for outpatient benefits assuming constant claim cost of 1000 € per capita with respect to male and female insureds respectively

Focussing on inpatient benefits we find some interesting insights. Total claims cost for males aged 65 and below made up 46% of total health care expenditure in 2009 but only 29% in 2019. Thus, medical claims for the part of the population that is potentially economically active, i.e. under the age of 65, made up a decreasing part of total health care expenditure.

Discussing the lower quartile, we find that 75% of medical expenses were attributable to males aged 57 and above in 2009. In 2019 three quarter of total health care expenditure referred to ages 64 and above. Hence, the vast majority of total private medical claims is paid to ever older people.

Let us assume that the trend of the historic evolution of the curve towards the lower right corner continues into the future. For most percentiles, we observe a horizontal shift to the right at the magnitude of about six years of life per decade. As a consequence, the median would increase from age 72 in 2019 to age 90 in
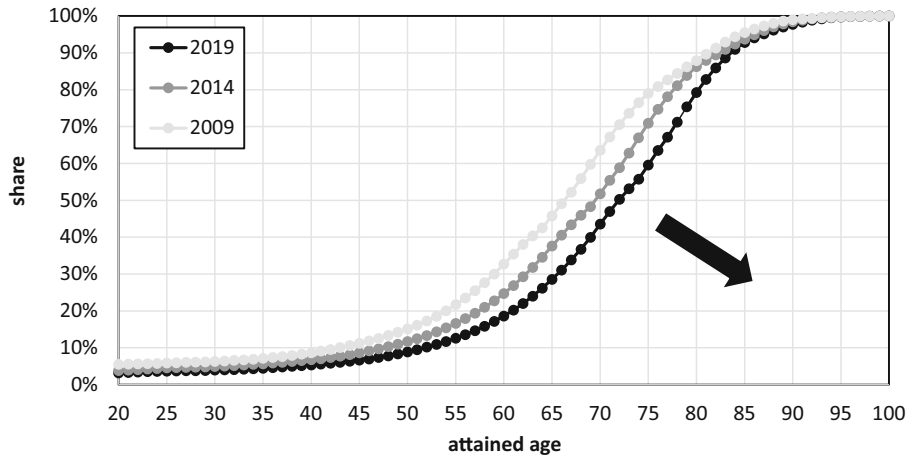
Fig. 8 Cumulative claims cost for inpatient benefits for male insureds over time

2049. I.e., in 2049 50% of all medical inpatient claims would be caused by peopled aged 90+. In 2019, on the other hand, the share of total inpatient medical expenses relating to ages 90 and above was 2.2% only.
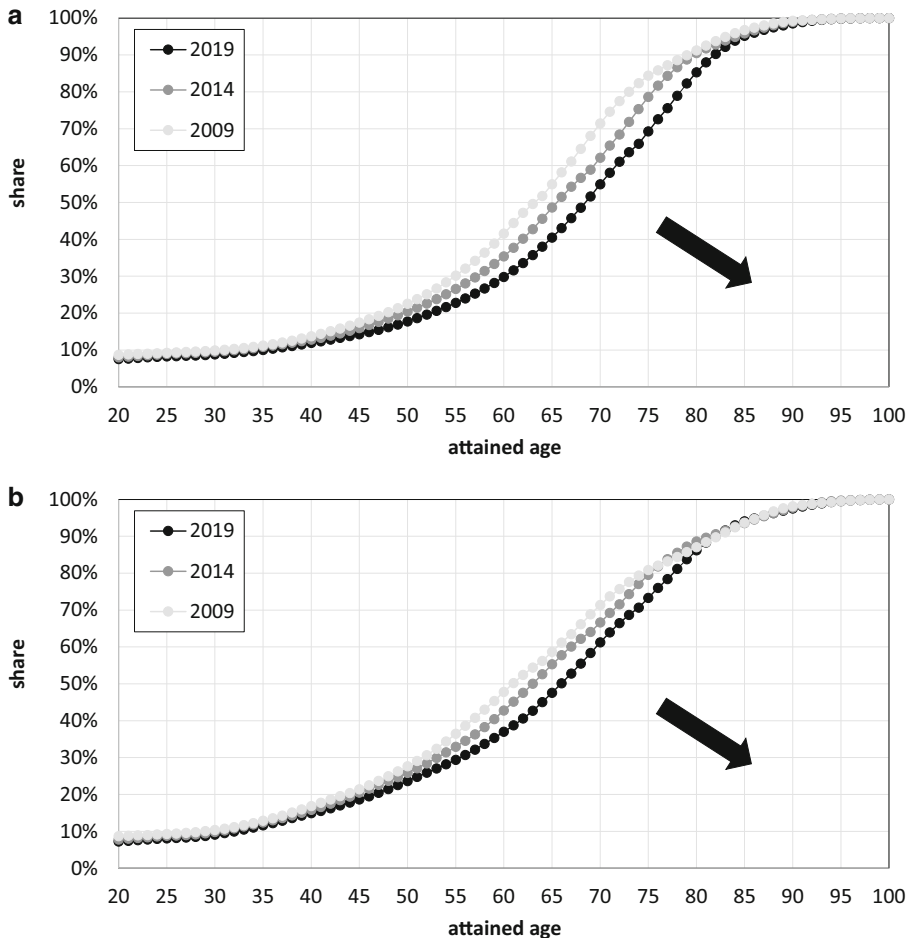
The curve of cumulative health care expenditure remains rather flat for longer and longer. Then, at ever higher ages, cumulative expenses steeply rise to reach 100%. This finding with respect to private medical expenses is in line with observations fist made by Nusselder and Mackenbach (1996) in Dutch demographics concerning the so called rectangularisation of the survival curve: More and more people reach a very high age before most of them die relatively quickly.

There also is a clear trend towards a more rectangular shape of the health care expenditure curve. We call the effects described above and presented in Fig. 8 as the rectangularisation of the cumulative total health care expenditure curve. The finding remains valid for both sexes and outpatients benefits as Fig. 9 exhibits.

5 Steepness and steepening

We showed that the average claim amount per capita increases with age for all benefit types and most ages. In this section we analyse the slope as well as changes in the slope.

Buchner and Wasem (2006) defined steepness by analysing health expenditure in the dimensions of attained age and calendar year. A claims profile is supposed to become steeper if in two given calendar years if claims cost for older people increase more than for younger people. Felder et al. (2010) define steepness by the partial cross derivative of health care expenditure by age and calendar year. Gregersen (2014) found evidence of steepening when a applying a methodology in line with Felder et al. (2010). Similarly, Gregersen did not reject steepening for inpatient benefits in relation to the age group 50+ when applying the methodology of Buchner and Wasem (2006).

Fig. 9 Cumulative claims cost for outpatient benefits with respect to male and female insureds respectively over time

In general, the slope of the health care expenditure per capita curve must be defined locally by the slope of the tangent. As we are interested in broader age ranges, we fit a straight line to the health care expenditure curve by applying a linear regression model. As such, the slope of the approximated linear function is taken as the slope of the given health care expenditure curve. Our task then is to analyse changes in the slope over time with respect to a given age range.

Notably, we apply a linear approximation applicable to an age band instead of considering the tangent for each individual age. As such, or modelling approach still constitutes a local fit. We choose an appropriate age range and estimate goodness of fit.

For each benefit type we identify an age band where the linear approximation suitably covers a comparatively large age range. Obviously, our modelling approach is broadly valid albeit results for other age bands will be different. In this sense, the

results presented in the following may be viewed for illustration purposes and proof of concept.

5.1 A linear model

We model average health care expenditure per capita $h(x)$ by

$$h(x) = f(x) \cdot {}_k q_x + g(x) \cdot {}_k p_x$$

Thereby, ${}_k q_x$ is the probability that an x year old male dies with the next k years and the complement ${}_k p_x = 1 - {}_k q_x$ is the probability that an x year old male survives the next k years. Equivalently, we find

$$h(x) = g(x) + (f(x) - g(x)) \cdot {}_k q_x$$

In this modelling approach, $f(x)$ is the medical cost of death and $g(x)$ is the medical cost for survival. Alternatively, we may interpret $g(x)$ as the base cost applicable to every insured person and $(f(x) - g(x))$ as the add-on cost of death. Furthermore, we assume that the estimated average claim amount is given by

$$\widehat{h}(x) = \widehat{a} + \widehat{b} \cdot {}_k q_x$$

In essence, we apply a linear model with ${}_k q_x$ being the regressand and $\widehat{h}(x) = \widehat{h}({}_k q_x)$ being the regressor. In the following, we set $k = 2$ for illustration purposes and apply the regression for each calendar year $t \in [2009; 2019]$, i.e. to data for the last available decade.

5.2 The Siegel test

Siegel ([2002](#)) devised a statistical test to compare two claims cost profiles. Our aim is to judge whether the average medical claim cost profile by age $h_{t_0}(x)$ for a given calendar year t_0 and its estimator $\widehat{h}_{t_0}(x)$ deviate by chance. The statistical hypothesis H states that both profiles are the same for all ages.

According to Siegel ([2002](#)) it is necessary to normalise both profiles. Then, normalisation implies stochastic independence. Furthermore, we need to know volatility of claim amounts. As this information is lacking in BaFin ([2021](#)) data we rely on specific recommendations by Siegel ([2002](#)). Finally, Siegel showed that the test statistic is asymptotically distributed chi squared.

As for illustration purposes and proof of principle, we first consider outpatient benefits and restrict our analysis to values of ${}_2 q_x$ between 0.009 and 0.0014. The associated age range is between 40 and 65 in 2019. As for inpatient benefits, we consider ${}_2 q_x \in [0.0025; 0.0125]$ which relates to $x \in [49; 64]$ in 2019 The ranges for hospital cash cover are ${}_2 q_x \in [0.0009; 0.009]$ and $x \in [40; 60]$ in 2019 respectively. Note that hospital cash cover is available to ages from 21–65 only. Finally, for dental insurance we set ${}_2 q_x \in [0.0027; 0.0135]$ which implies $x \in [50; 65]$ in 2019.

The modelling results are as follows (Table [3](#)).

Table 3 Modelling results with respect to male insureds

Calendar year t	Inpatient benefits		Outpatient benefits		Hospital cash cover		Dental insurance	
	R^2	T	R^2	T	R^2	T	R^2	T
2009	1.00	20	0.99	24	1.00	13	0.98	20
2010	1.00	25	1.00	13	1.00	6	0.97	25
2011	0.99	45	1.00	12	–	–	0.97	23
2012	0.99	41	1.00	12	1.00	2	0.96	29
2013	1.00	10	1.00	15	1.00	1	0.97	23
2014	1.00	7	1.00	13	1.00	1	0.97	24
2015	1.00	7	1.00	9	1.00	1	0.97	24
2016	1.00	8	1.00	5	1.00	2	0.97	25
2017	1.00	9	1.00	4	1.00	0	0.98	17
2018	1.00	8	1.00	3	1.00	0	0.99	10
2019	1.00	9	1.00	3	1.00	4	0.99	8

Fig. 10 Average claim amounts per head for inpatient benefits in 2019 with respect to male insureds
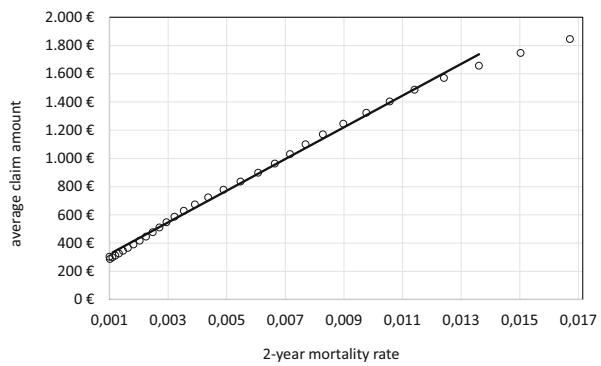
To sum up, we selected suitable age ranges for each benefit type in such a way that the linear regression exercise results in a near perfect fit. Goodness of fit is proven by applying the Siegel test. Therefore, we may interpret the slope of estimated linear function as the slope of the curve for health care expenditure per capita with respect to the chosen age interval.

For illustration purposes we plot raw average claim amounts per head as well as estimated ones for inpatient benefits (see Fig. 10). It becomes clear that the approximation constitutes a local good fit.

5.3 The slope of the health care expenditure per capita curve

Based on the linear model above we analyse the slope of the estimated straight line in the given age interval for each benefit type and each calendar year. Results are summarised in Table 4.

We define steepening as the slope getting bigger over time. Rather than considering the tangent for every age we use the estimated straight line over a given age range instead. In particular, we observe steepening of average private medical expenses per capita with respect to inpatient benefits, outpatient benefits and den-

Table 4 The evolution of the slope of estimated average claims per head from 2009–2019 with respect to male civil servants

Benefit type	Age range	Slope 2009 $\widehat{b}_{2009}$	Slope 2019 $\widehat{b}_{2019}$	Relative change $\widehat{b}_{2019}/\widehat{b}_{2009} - 1$ (in %)
Inpatient	[40; 65]	112,293	121,737	8.4
Outpatient	[49; 64]	151,846	159,804	5.2
Hospital cash	[40; 60]	748	690	−7.7
Dental	[50; 65]	21,890	27,139	24.0
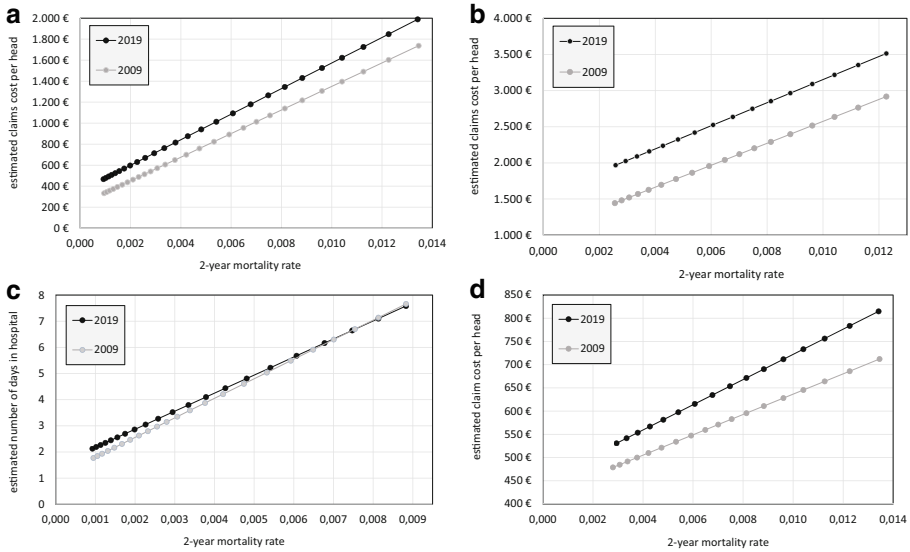
Fig. 11 Estimated claims cost 2009 versus 2019 for all benefit types with respect to males

tal insurance. Steepening is most pronounced for dental insurance. Moreover, the change in the slope is bigger for inpatient benefits than for outpatient benefits. Finally, we observe flattening, i.e. the opposite of steepening, relating to hospital cash cover from 2009–2019.

For illustration purposes, we plot estimated average claim amounts per head relating to calendar years 2009 and 2019. Note that we have analysed goodness of fit in the previous section as per Table 3 and Fig. 10. We therefore omit the original health care expenditure curve in Fig. 11. In order to judge the slope and its changes over time we have to consider the estimated straight line instead.

6 The evolution of private medical expenses

Building on our linear regression model we want to better understand the evolution of average private medical claims per capita as plotted in Figs. 3 and 4. Our approach is motivated by physics.

Consider the gravitational force that acts on a car standing on a slope of a hill. The force can be additively decomposed into two forces. The first acts in parallel to the slope and makes the car move downhill. The latter is called adhesive force and keeps the car on the road. The sum of downhill force and adhesive force is the gravitational force.

Likewise, we assume that the change in average claim cost per head over time is caused by two effects: compression and medicalisation. The first stretches the profile and shifts the curve to the right. The latter moves the curve upwards.

Therefore, we decompose a given profile of average claim cost per head into two functions:

$$\widehat{h}_t(x) = c_t(x) + m_t(x)$$

whereas we define

$$c_t(x) = \widehat{a}_{t_0} + \widehat{b}_{t_0} \cdot {}_k q_x^t$$

and

$$m_t(x) = c_t(x) + \widehat{a}_t - \widehat{a}_{t_0} + \widehat{b}_t \cdot {}_k q_x^t - \widehat{b}_{t_0} \cdot {}_k q_x^t$$

We call function $c_t(x)$ the compression effect. Compared with the estimated claims profile $\widehat{h}_{t_0}(x)$ in year t_0 it causes a shift of this curve to the right. Then, the only difference is that we apply ${}_k q_x^t$ instead of ${}_k q_x^{t_0}$ when computing $c_t(x)$.

We call function $m_t(x)$ the medicalisation effect. It causes a shift of function $c_t(x)$ upwards. The sum of compression effect and medicalisation effect yields the estimated claims profile $\widehat{h}_t(x)$ in year t which can be easily verified.

For illustration purposes, we set $t_0 = 2009$ and $t = 2019$ and consider outpatient benefits as well as inpatient benefits for the age group of 70–79 (see Fig. 12).

As a result, medicalisation is more pronounced with respect to outpatient benefits. As for inpatient benefits, medicalisation has a comparatively smaller impact on the evolution of health care expenditure per capita over time. Thus, compression is
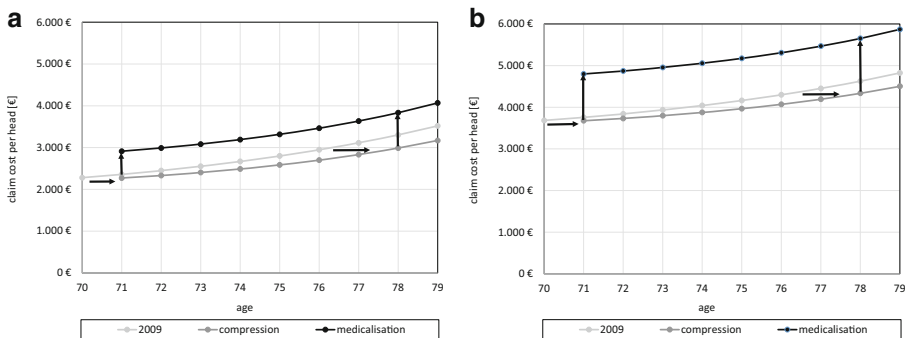
Fig. 12 Decomposition of the change of average claims cost per head between 2009 and 2019 for outpatient and inpatient benefits with respect to male insureds

of higher relative importance with respect to inpatient cover while medicalisation dominates changes over time relating to outpatient cover.

7 Conclusion

In this article, we studied secondary statistics relating to private medical insurance in Germany. The data published by the German supervisory authority BaFin is used by insurance companies for pricing purposes and may therefore be deemed as a useful data source.

There are certain limitations to this study as we analysed secondary data only. Any change over time in producing these private medical insurance stats which are the basis for our analysis may not be known to BaFin and subsequently to us. Note that we analyse market data collected from all private medical insurance companies in the market. Any changes in data collections procedures may not be revealed to BaFin either. For instance, we observed a change in the average claims amount with respect to inpatient benefits for female insureds in 2019. As it is not possible for us to get to the bottom of these observations we primarily, but not exclusively, focussed on male civil servants. This part of the data makes up the bulk of private medical insurance business in Germany and does not exhibit any strange abnormalities.

A first descriptive analysis revealed that health care expenditure per capita rises with attained age, especially with respect to inpatient and outpatient benefits provided to older ages. As for outpatient benefits provide to male civil servants, for instance, annual rates of increase were more than two percent per year on average for almost all age groups.

We then shed light on the driving factors behind this development. It is a well known fact in demographics that the modal age of death at which most people die has significantly increased over time. Likewise, we found out that the modal age at which health care expenditure is highest has also increased. As for inpatient benefits for male civil servants the modal age has increased from age 69 in year 2009 to age 79 in year 2019, for instance. We found out that population ageing is the driving factor for this development.

In demographics the increase of the modal age of death over time is associated with an effect called the rectangularisation of the survival curve. More and more people reach a high age before dying relatively soon thereafter. We revealed an analogous effect that we call the rectangularisation of the health care expenditure curve. An ever larger share of total medical expenses is attributable to ever older people. A small part of total health care expenditure is sufficient to cover an increasingly large age band.

We then analysed the slope of the health care expenditure per capita curve by age over time. To broaden the scope, we applied a linear regression model based on mortality rates. In essence, we assume that health care expenditure per capita is given by the sum of the cost for maintaining good health as well as the cost of death. We proved goodness of fit by applying the Siegel test.

Notably, we observed rising average medical claim cost per head within the given age ranges for all benefit types. Thereby, we define steepness of the underlying health

care expenditure curve by a positive slope of the estimated straight line. In particular, we note an increasing slope, called steepening, over time with respect to inpatient and outpatient benefits as well as dental cover. As for hospital cash cover, we found flattening of health care expenditure per capita by age over time.

Finally, we considered the evolution of claims cost profiles. To do so, we isolated two effects on the health care expenditure per capita curve over time: a shift to the right and a shift upwards. The former is called compression effect, the latter is called medicalisation effect. The compression effect takes the ageing effect within the population into account. Consequently, over time, the cost of death is referred to a higher age. The medicalisation effect on the other hand refers to the general effect of price trends on medical expenditure. Reasons may be medical inflation, advances in medical technology and increased take-up rates for certain procedures, to name but a few.

Comparing the effects, we found out that the compression effect is of relatively high importance with respect to inpatient benefits. The medicalisation effect dominates the evolution of health care expenditure with respect to outpatient cover. These two findings may be correlated by the fact that there is a trend to outsource certain medical procedures from hospitals into day clinics such as cataract surgeries.

As for future research we suggest validating our findings on primary statistics of private medical insurance companies or national health services respectively, possibly all over of the world. It would be very interesting to learn more about the evolution over time of heath care expenditure per capita in general and the impact of compression and medicalisation in particular in other countries. By so doing, we would gain a deeper understanding of the evolution of health care expenditure all in general as well as compression and medicalisation in particular. It would also be useful to analyse steepness and steeping more comprehensively for more age bands based on our concept of linear approximation. Last but not least, the insights gained in this study may be helpful with respect to projecting medical expenses into the future on a population level.

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