Comparison of Different Implementations of a Process Limiting Pharmaceutical Expenditures Required by German Law

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Abstract: German legislation demands controlling measures for outpatient drug costs. As of 2017 the health insurance actors rose to a challenge to reform the benchmark system on the federal state level. We look at the previous system applied until 2015, the improvements in 2016 and the method the regional parties agree on for 2017. After discussing hard- and software systems and the underlying data briefly we describe the flaws of the old approach and develop a general model for controlling measures in the outpatient field. Finally we present the first real world applications of the new model: a patient type classification system leading to target costs and a derived distance structure of physicians regarding their prescription behaviour.

1 INTRODUCTION

In Europe and especially in Germany rising pharmaceutical expenditures put the health service at risk. Every modern health care system has to ensure the quality and equity of care while keeping the cost down. Therefore controlling measures were established by the German legislation as early as in 1993. Since 1995 this is subject to regional negotiations between Statutory Health Insurances (SHI) and SHI associated physicians. This type of regulation aims to limit expenditures per patient without restricting the necessary treatment.

Of the exiting two types of instruments, the first one puts German patients/cases in certain more or less morbidity related cost groups, the other promotes or restricts drug classes with different economic characteristics but same curative effects. We will look at those using health insurance data of the German Federal State Schleswig-Holstein in 2015.

In the years from 1995 till 2015 physician groups got three different treatment case budgets for each insurance status defined by statutory health insurance (member [M], dependent coverage [D] and retired [R]). Some regions merged status [M] and [D]. Several expensive drug substances and pharmaceuticals regulated by treatment regimen are excluded resulting in internal inconsistencies and uncertainties regarding all participating players.

Budgets are calculated using expenditure shares for the mentioned case groups per physician group in a reference period (last year) and the negotiated target volume of expenditure for the resent year.

In December 2013 the social welfare court of Dresden passed the sentence that guide values/budgets have to be based on age groups. Additionally the Federal Social Court judged that authorities have an obligation to regulate atypical drug prescriptions. As an immediate consequence regarding the budget calculation for 2016 four age groups superseded insurance status: 0-15, 16-49, 50-64 and 65 and above. Those groups, utilized in all statutory health insurances, have a very poor age resolution for this field of application in general.

From 2017 on, the federal legislator made regional negotiated far-reaching reforms of controlling measures possible (Versorgungsstärkungsgesetz = Supply Support Act). A new system developed in this context is expenditure controlling by Morbidity Related Groups (MRG). MRG is an adaption of

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the Diagnosis-Related-Group-System (DRG) used for classification and compensation of hospital cases and put into effect in 2003 by German legislation. It is based on similar systems elsewhere: Since the first use for hospital payment in the United States in the early 1980s, DRG-type systems have become the main method of hospital payment in the majority of OECD countries. The German version (G-DRG) is based on the Australian DRG-system (AR-DRG).

Hereinafter we will compare the systems based on insurance status, age groups and MRG, including some new results for MRG.

2 MATERIAL AND METHODS

For comparing the previous and the new controlling measures we analyze detailed prescription data of the Statutory Health Insurance in Schleswig-Holstein of quarter two in 2015. There's no benefit using annual data due to the stable prescription framework. The data on the prescription level are combined with master data containing drug classes (ATC [anatomic-therapeutic-chemical] with some additions for products not classified), physician groups and drugs to be excluded. Treatment cases of the Association of Statutory Health Insurance Physicians are also added. Obtaining results required the processing of large amounts of data.

The hardware used is a dedicated Debian GNU/Linux Server administered by the Medical Advisory board of Statutory Health Insurance in Northern Germany also used to generate consultation materials from the same data.

It runs a LAMP configuration (Debian GNU/Linux, Apache 2.4, MYSQL Community Edition 5.7 [extensive use of partitioning] and PHP 7 [with PEAR framework esp. for spreadsheet output]). The inexpensive open source/free software setup makes the cooperation of different administrative bodies possible. The coding was done using the Perl programming language.

The previous model used till 2016 applies prescription data, treatment cases and status defined by statutory health insurance/age groups. The implementation is straight forward. Treatment cases in a certain age/status group get their share of the negotiated volume of expenditure based on the development of last years‘ expenditures and treatment cases.

The new MRG-model requires prescription data, the ATC classification and physician group information depending on the model configuration. It can be defined as follows:

$B =$ set of physicians/practices

$F =$ set of physician groups

There is a transformation mapping physicians/practices to groups: $f = f(b)$ while splitting up practices containing different physician groups.

$P(b)$ = patients of $b \in B$, $b = b(p)$ is the mapping of patients and physicians whereas the transformation $D = D(p)$ maps patients $p \in P(b)$ to the prescribed drugs. Multiple prescriptions of one drug are counted repeatedly. $o(d)$ is a quantity factor for $d \in D$ representing the ration of package size of the prescription drug in relation to the biggest one available. A pharmaceutical classification system (e.g. ATC4) as transformation: $a = a(p), a \in A$ used identification of similar medicinal products. The drugs $d \in D$ are linked to costs by the cost function: $k = k(d), k \in \mathbf{R}, k > 0$.The age of the patient is defined by: $t = t(p)$ in five-yearly stages. A MRG is a pair $d = (c,s)$ [c:basic MRG, s:degree of severity] with $c \in A, s \in \mathbf{Z}, 0 \leq s \leq 9$.

$$\text{Cost per ATC} = \bar{k}(p,a^*) = \sum_{d \in D(p), a(p)=a^*} k(d)$$

ATC with the highest costs = basic MRG is characterized by $\bar{k}(p,c) \geq \bar{k}(p,a)$ for all $a \in A$. In case of the occurrence of several c_i the lexicographically dominating element is chosen. $c = c(p)$ is the transformation to determine patients basic MRG. Number of ATC4 groups per patient (multimedication) is defined as:

$$v(p) = \#\{a \in A : \bar{k}(p,a) > 0\}.$$

The number of prescriptions for patient $p \in P$ assigned to basic MRG $c(p)$ is represented by:

$$\bar{o}(p) = w\Big(\sum_{d \in D(p): a(d)=c(p)} o(d)\Big) \text{ with}$$

$$w(x) = \begin{cases} x, \text{ if } x \in \mathbf{Z} \\ \lfloor x \rfloor, \text{ if } x \notin \mathbf{Z}. \end{cases}$$

We define threshold values for subgroups:

$$(v_0, \cdots, v_9) = (0.5, 0.75, 1.25, 1.5, 2.0, 2.5, 5, 10)$$

$i(v) = i$ is true if $v_i \leq v < v_i + 1$. $m(X)$ shall be the mean of $x \in X$. The costs of basic MRG $c \in A$ in the physician group are defined as:

$$k_1^*(c^*, f^*) = m_{p \in P: f(b(p))=f^*, c(p)=c^*} \Big(\bar{k}(p,c^*)\Big)$$

and adding the age dimension the term changes to:

$$k_1^*(c^*, f^*, t^*) = m_{p \in P: f(b(p))=f^*, c(p)=c^*, t(p)=t^*} \Big(\bar{k}(p,c^*)\Big)$$

whereby the age related severity is given by:

$$i_1(c,f,t) = i\Big(k_1^*(c,f,t)/k^*(c,f)\Big).$$

Costs differentiated by multimorbidity are expressed by the formula:

$k_2^*(c^*, f^*, j^*) = m_{p \in P: f(b(p))=f^*, c(p)=c^*, v(p)=j^*}\left(\bar{k}(p, c^*)\right)$
with the corresponding degree of severity:

$$i_2(c, f, j) = i\left(k_2^*(c, f, j)/k^*(c, f)\right).$$

The same can be done by looking at prescription intensity:
$k_3^*(c^*, f^*, j^*) = m_{p \in P: f(b(p))=f^*, c(p)=c^*, \bar{o}(p)=j^*}\left(\bar{k}(p, c^*)\right)$

$$i_3(c, f, j) = i\left(k_3^*(c, f, j)/k^*(c, f)\right).$$

Total degree of severity is given by:
$$i(p) = max\Big(i_1(c(p), f(b(p), t(p)), i_2(c(p)), f(b(p)), v(p)), i_3(c(p)), f(b(p), \bar{o}(p))\Big).$$
The MRG including severity levels is recalculated with respect to physician groups:
$k_g^*(c^*, f^*, j^*) = m_{p \in P: f(b(p))=f^*, c(p)=c^*, i(p)=j^*}\left(\bar{k}(p, c^*)\right).$
Thereby we get the target cost for benchmarking the physician:

$$k^\# = \sum_{p=P(b)} k_g^*\left(c(p), f(b(p)), i(p)\right).$$

In our setting we look for the group with the highest drug costs within a quarter for each consulted physician for a certain patient. This group should strongly be related to the morbidity of the patient and we will call it therefore Morbidity Related Group (MRG). One considers the costs as a proxy for the severity of drug treatment and could also take other weight functions instead of cost. The following is an example regarding a diabetes patient who belongs to the basic group A10A (Insulins and analogues) with total patient cost of 1,536.75 €:

Table 1: Example of (basic) MRG determination.

cost	nr	ATC	substance	drug	amount
320.74	1	B01AF01	Rivaroxaban	XARELTO 15 mg	98
272.61	1	N06AX21	Duloxetine	CYMBALTA 60 mg	98
248.02	2	A10AD04	Insulin Lispro	LIPROLOG Mix 25	10X3
208.25	7	V04CA02	Glucose	CONTOUR Teststreifen	50
159.35	1	N02AA55	Oxycodone	TARGIN 10 mg/5 mg	100
124.01	1	A10AD04	Insulin Lispro	LIPROLOG Mix 50	10X3
112.35	1	N02AA55	Oxycodone	TARGIN 5 mg/2.5 mg	100
23.97	1	C10AA01	Simvastatin	SIMVA ARISTO 40 mg	100
19.22	1	C03CA04	Torasemide	TORASEMID AL 20 mg	100
16.27	1	N02BB02	Metamizole Sodium	NOVAMINSULFON 1A	100
15.41	1	H03AA01	Levothyroxine Sodium	L-THYROX HEXAL 125	100
13.98	1	C07AB12	Nebivolol	NEBIVOLOL Glenmark 5 mg	100

As an initial adjustment factor the age of patients can be applied. In each 5 year group of patients the ratio of costs per patient in the subgroup compared to the whole MRG was considered. If the ratio lies in certain intervals (0-0.5, 0.5-0.75, 0.75-1.25,..., 10) the age severity level 0,1,...,9 were assigned. The same can be conducted with respect to other factors correlated with morbidity. By using subgroup structures a risk adjustment can be accomplished. All of this has not to be precise on the level of the patient but on the physicians level. Regarding the considered MRG A10A (Insulins and analogues) seven degrees of severity in the range of 101.27 € up to 1,385.61 € resulted:

Table 2: Example of severity levels of MRG A10A.

degree	cost in Euro	number of patients
2	101.27	21
3	273.68	60,634
4	517.87	16,840
5	707.95	20,904
6	995.74	2,085
7	1,385.61	1,954

We divide the (basic) MRG into several severity levels that will be analysed by Lorenz curves and the corresponding Gini coefficients: Additionally the

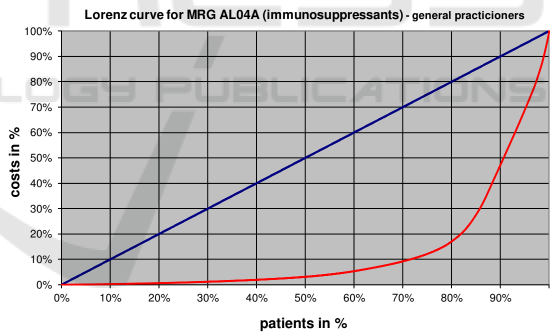

Figure 1: Lorenz curve of MRG AL04A.

Shannons entropy $(-\sum p_i log(p_i))$ can be applied to the patient type structure in each physicians group with respect to the MRG basic groups:

Table 3: Shannon entropy per physician group (1).

enthropy	number of patients	physician group
3.9985	994,220	general practitioners
3.8156	95,054	paediatricians
3.5635	3,548	non-specialised internists
3.4234	4,991	nephrologists
3.1437	1,955	haematologist/oncologists
3.1149	3,285	cardiologists
2.9632	2,961	gastroenterologists

Table 4: Shannon entropy per physician group (2).

enthropy	number of patients	physician group
2.7608	84,660	dermatologists
2.7552	16,155	surgeons
2.7327	40,045	neck nose ear physician
2.6253	91,868	gynaecologists
2.4939	37,199	urologists
2.2263	49,653	neurologists
2.1716	1,325	endocrinologists
2.1210	3,851	rheumatologists
2.0282	40,149	orthopaedic
1.6552	2,123	anaesthetists
1.4179	51,819	ophthalmologists
1.3517	26,392	pulmonologists
1.1722	7,003	psychiatrists

3 RESULTS

The application of the treatment case oriented approaches over the last decades showed that these systems are incapable of considering age and progress related increase of prescription costs. Recent analysis of the age distribution of treatment cases in each Statutory Health Insurance status group shows that the applied age groups might be too coarse and unsuited as the insurance status for the morbidity related depiction of prescription costs per patient:

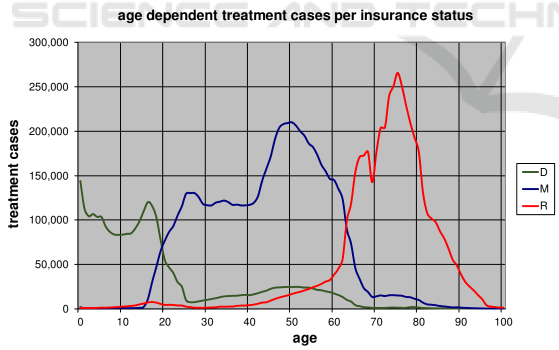

Figure 2: Age dependent number of treatment cases per insurance status/age groups.

The high correlation of the results of the two methods applied until 2016 confirms that shifting to age groups on the physicians level had practically no benefit:

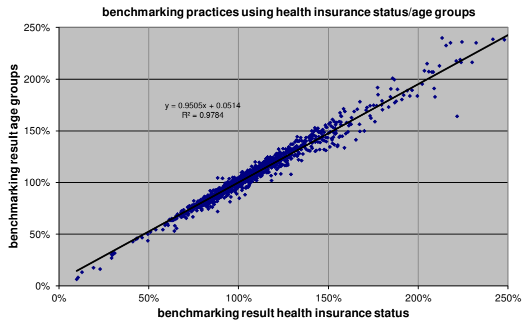

Figure 3: Correlation of benchmarks using health insurance status vs. age groups.

Hence, a new system based on MRG is introduced in 2017. There is little correlation between the results obtained by the previous and the new results on the practitioners level. That‘s due to the fact that many factors were disregarded in the past and inconsistencies were compensated by “manual intervention“:

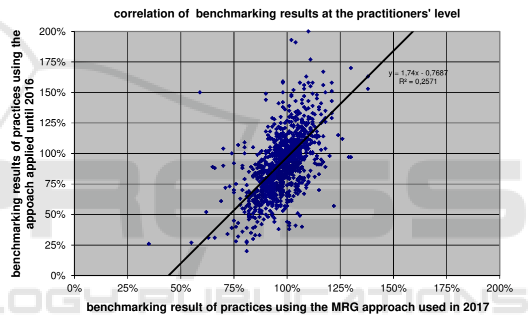

Figure 4: Correlation of benchmarks applying the previous (until 2016) and the new approach (2017).

Sorting the practices in ascending order for all affected groups due to their MRG benchmarking result and comparing those to the outcomes of the older system demonstrates the progress in model adaption made:

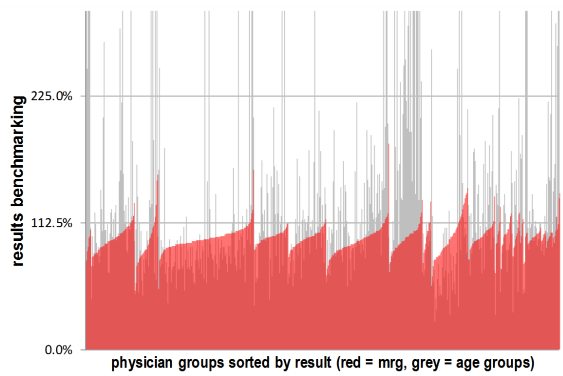

Figure 5: Results of MRG vs. system based on treatment cases in 2016 (each line one practice).

In those new MRG models all patients of a certain practice are classified and a specific structure for each practice is the result. As an example, we consider a physician with 14.0 % of his patients in the MRG A10A (Insulins and analogues) and 11.8 % patients in the MRG V04C (other diagnostic agents = test strips measuring glucose). In this group of general practitioners (GP) patients in those groups only account for 3.8 % in these two groups. The physician can thereby be identified as a diabetologist:

Table 5: Patient structure of a diabetologist.

nr	MRG	nr. pat.	cost per patient	prop. doc.	prop. group	drug droup
1	A10A	193	463.12	14.0%	2.4%	Insulins and analogues
2	V04C	162	307.76	11.8%	1.4%	Other diagnostic agents
3	H03A	86	22.28	6.3%	4.5%	Thyroid preparations
4	A10B	82	185.78	6.0%	2.7%	Oral blood glucose lowering drugs
5	A02B	73	60.91	5.3%	7.2%	Drugs for peptic ulcer and gastro-oesophageal reflux disease (gord)
6	B01A	53	366.21	3.9%	4.0%	Antithrombotic agents
1	J01D	22	31.70	1.6%	2.4%	Other beta-lactam antibacterials
19	C10A	17	58.30	1.2%	3.0%	Cholesterol and triglyceride reducer
20	N03A	16	275.63	1.2%	1.4%	Antiepileptics

After the formation of groups for all practices/physicians one can compare the MRG distributions and values in each group:

Table 6: MRG patient shares of orthopaedics.

frac. pat.	cost p. pat.	MRG	drug group
42.9%	19.95	M01A	Antiinflammatory and antirheumatic products, non-steroids
13.6%	26.26	H02A	Corticosteroids for systemic use, plain
12.4%	23.81	N02B	Other analgesics and antipyretics
8.2%	134.66	M05B	Drugs affecting bone structure and mineralization
6.1%	123.78	N02A	Opioids
3.6%	92.18	B01A	Antithrombotic agents
3.3%	40.71	M03B	Muscle relaxants, centrally acting agents
2.5%	33.75	A02B	Drugs for peptic ulcer and gastro-oesophageal reflux disease (gord)
1.1%	2,515.02	L04A	Immunosuppressive agents
1.0%	304.63	L01B	Antimetabolites

Regarding orthopedics we observe a patient type structure, in which 42.9 % of all patients belong to the MRG M01A (antiinflammatory and antirheumatic products, non-steroids). The 10 leading positions cover 94.6 % of the costs. Costs again depend mainly on the medical discipline. In oncology average costs per patient are 15,288.17 € in the MRG L04A (immunosuppressive agents including all the other drugs for the patient) versus 2,515.02 € for orthopedics. In urology the top ten positions with respect to the number of patients cover 83.6 % of the costs. In the case of GP these costs are only 44.2 %:

Table 7: MRG patient shares of urologists.

frac. pat.	cost p. pat.	MRG	drug group
34.8%	44.67	G04C	Drugs used in benign prostatic hypertrophy
16.7%	136.12	G04B	Other urologicals, incl. antispasmodics
9.9%	19.84	J01M	Quinolone antibacterials
6.8%	618.61	L02A	Hormones and related agents
4.9%	30.42	J01X	Other antibacterials
3.1%	33.47	J01D	Other beta-lactam antibacterials
2.0%	154.56	G03B	Androgens
1.9%	22.13	J01E	Sulfonamides and trimethoprim
1.7%	27.71	D01A	Antifungals for topical use
1.7%	4,122.10	L02B	Antimetabolites

Table 8: MRG patient shares of general practitioners.

frac. pat.	cost p. pat.	MRG	drug group
7.3%	62.55	A02B	Drugs for peptic ulcer and gastro-oesophageal reflux disease (gord)
5.4%	42.04	C07A	Beta blocking agents
5.1%	34.67	M01A	Antiinflammatory and antirheumatic products, non-steroids
4.7%	24.25	H03A	Thyroid preparations
4.2%	185.14	R03A	Adrenergics, inhalants
3.8%	316.40	B01A	Antithrombotic agents
3.8%	124.59	C09D	Angiotensin II antagonists, combinations
3.4%	85.10	C09C	Angiotensin II antagonists, plain
3.4%	30.68	C09A	Ace inhibitors, plain
3.2%	88.42	N06A	Antidepressants

The MRG patient shares can be utilized to generate distance measures for the clustering of all practices/physicians. Let p_m^k be the fraction of patients with MRG m $(m \in M)$ for the physician k $(k \in P)$. With respect to the medical discipline s $(s \in S)$ and let q_m^s be the respective fraction. Let r and s be such fractions for physicians or medical disciplines we can use a Manhattan distance:

$$\sum_{i \in M} |r_i - s_i|$$

Alternatively we can apply spherical distances on the n-dimensional sphere where n is the number of MRG classes with respect to the points:

$$\frac{r_m}{\sqrt{\sum_{j \in M} r_j^2}} \text{ and } \frac{s_m}{\sqrt{\sum_{j \in M} s_j^2}} \text{ or } \sqrt{r_m} \text{ and } \sqrt{s_m}$$

The spherical distances are differentiable with respect to the components of r and s and thereby is more suitable for optimization procedures.

We can define the discipline $t \in S$ of a physician $k \in P$ by the value $s \in S$ for which:

$$\sum_{m \in M} |p_k^m - q_m^s|$$

has a minimal value. The distance of a physician to a group measures to which extent he is typical or not. Extreme values may be a hint for the need for special considerations. One can use cluster methods in order to receive a classification of physicians without the use of their medical discipline which is primarily determined by admission law.

4 CONCLUSIONS

The 2016 switch from health insurance status to age groups did not eliminate the flaws of the old benchmarking/budget approach. New promising ideas on the regional level like MRG have a huge potential still to be researched and utilized. The necessary data is provided, hard-/software and knowledge are available. Steady change and especially new form of health care require adapting benchmarking systems on a sound data and legal foundation. Therefore MRG seems to be a highly suitable approach meeting the criteria.

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