Possibilities for the development of a risk-adjusted, person-level capitation formula in Hungary

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University of Eötvös Loránd
Faculty of Social Sciences
Doctoral School in Sociology

Author:
Petra Fadgyas-Freyler

Supervisor:
Prof. Éva Orosz, DSc
Head of Doctoral Programme in Social Policy

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INTRODUCTION

We can clearly state that financial sustainability of healthcare systems has become a worldwide issue. Due to both technological innovations and ageing populations policy makers are under pressure to find a solution for the conflict between rising prices of medical therapies and strict budgets. The affordability of cutting edge health technologies is causing some headaches even in richer countries.

As there is little space for loosening financial restraints, health policy makers are eagerly looking for tools for more efficient use of health resources. More attention is paid to the theory and practice of resource allocation techniques (Mossailos et al 2002, Langenbrunner et al, 2005, Busse et al, 2007). One of those measures is risk-adjusted capitation. Capitation is defining a given sum to be assigned to a person for a certain health service package for a given period of time that has to be paid to the purchaser organisation (insurance company or health authority). The amount is an estimate to be determined on the basis of the person's characteristics influencing his or her health utilisation. In theory, risk-adjusted capitation enables the most efficient use of the resources which means that with the given amount of available resources the maximum of health gain can be bought for the whole population. As a consequence of the capitation the health care system can work more efficiently and more equitably. In addition to that care management can be targeted according to risk-groups of the patients. (Rice&Smith, 1999, Nagy, 2009)

The allocation of health resources in the current Hungarian health care system is mainly based on previous spending, there is no strategic resource allocation formula in use, though the country has some experience with capitation through the former Managed Care Organisation pilot (from 1999 until 2009).

In terms of current distribution, it can be stated that more money flows to regions (counties) where health status – measured by mortality and HLYE – is better than average, and there are less resources (per capita spending) in regions with worse health status.

GOAL OF THE DISSERTATION

The goal of the dissertation was to develop a risk-adjusted capitation model that allows a more efficient and equitable model for the allocation of Hungarian health resources. It would do so by breaking away from historical distribution and taking into account the health needs and risks of the population. I wanted to elaborate a calculation method based on patient-level data that is able to estimate future expenses. The database of the model uses person-level data (n=9.7 million), the amount of resources handled covers roughly 80% of all payments for benefits-in-kind paid to providers by the single payer National Health Insurance Fund Administration (NHIFA). It is approximately 64% of all public health spending in 2015. Following sub-budgets of the Health Insurance Fund (HIF) are taken into account: outpatient specialist care, laboratories, CT/MRI scans, dialysis, dentistry, patient transport, hospice and home care, prescribing, medical devices, inpatient care. The services covered by these sub-budgets are mostly reimbursed with a fee-for-service or DRG-type payment method (with a volume-cup for each provider).

We know from international publications (Rice&Smith, 2001) what criteria have to be fulfilled for an adequate risk-adjusted capitation formula. Based on these, the main questions of the dissertation were:

- Are data available for factors which presumably influence health care utilisation? Can new data sources be identified for additional information on persons' characteristics influencing their health needs?
- When there are no data available, can we gain information from other sources substituting those data or denoting them?
- Is it possible to show statistical correlations between utilisation measures and the explanatory variables?
- Can the effects of supply and demand factors be distinguished respectively?
- Can the effects of the supply variables be controlled in the formula?

- Which statistical method can/should be used to develop a capitation based resource allocation system?
- Is it possible to develop a more efficient and equitable allocation method than the current one?

As a consequence the dissertation explored whether the present conditions allow an appropriate assessment of the individual's health needs or can such conditions be created. A methodology has been developed for a risk-adjusted capitation. The changes compared to current resource allocation have been shown in a breakdown to NUTS3 (county) and NUTS4/LAU1 levels (local administrative units).

The significance of the research lies in the fact that - as a result of a longer, experimental phase - a much more comprehensive normative capitation system has been elaborated with the help of completely new data sources. The dissertation – through methodological, practical, experimental and analytical work-processes – synthesized the international and Hungarian capitation experience into a new capitation system for the distribution of a significant proportion of health resources currently paid to benefits in kind. It is to be emphasised that we do not talk the transfer or implementation of an existing method but the elaboration of a country-specific model.

The significance of the work done is not only in the presentation of the results, but in the description of the path that led to them. Several interesting facts and correlations have been revealed during the calculations and analysis. With the help of real world data we have outlined the steps necessary for the development of a new model, such as searching and finding of appropriate data sources, cleaning of the data, their grouping, identification of main characteristics of the variables and preparation for later calculations. The results have proved the correctness of the methodology. With the description and elaboration of different alternative methods future development paths have also been outlined.

It should be emphasized that the model developed could only provide a starting point for further work. An actual implementation of the method would definitely require further developmental work, as well as elaboration of an implementation strategy.

Besides the actual findings regarding capitation several other long-term problems of Hungarian health financing have been addressed, such as the difference between the official residence of the insured and their actual place of dwelling. Also other, not known or not identified factors influencing health utilisation have come into light such as source of entitlement, or marital status.

METHODOLOGY

In order to develop a country specific risk-adjusted capitation system a literature review about the theory of strategic resource allocation system and its practice within three European countries of the Netherlands, England and Germany has been conducted. For the development of the new model following statistical methods have been applied:

1. For the exploring, understanding and analysis of the variables:
   covariance and correlation matrix calculations
2. For model building
   2.a. one-stage multivariate linear regression,
   2.b. a two-stage hurdle model in which probit regression was applied to estimate probabilities and the costs. For the later
      2.b.i.multivariate linear regression with health spending in its original form,
      2.b.ii.logarithm transformation for health spending was used in order to handle concentration and high costs.
      2.b.iii.generalized linear regression model of GLM (Generalised Linear Regression) was also applied.
   2.c. For the calculation of the capitation fees, an artificial intelligence method (random forest) was also used.

Literature Review

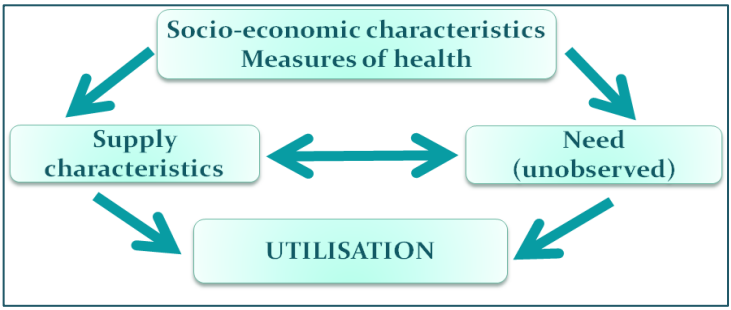
The literature review followed the snowball principle, the starting point of which was the institutional system of capitation calculations all over Europe. The authors of main summaries regarding capitation have been contacted via e-mail, skype etc. The literature review first highlights the role of capitation within the health financing system. As a second step it describes the different categorisation aspects of capitation systems and the two main concepts behind need-assessment (normative and utilisation approach). The various commonly used groups of performance indicators within the capitation systems is also presented. Finally the review outlines possible additional measures of the resource allocation systems (e.g. risk-sharing).

The second half of the literature review analyzes and describes the capitation systems used in Germany, the Netherlands and England thoroughly.

The empirical model

Theoretical approach

The empirical model developed in the dissertation largely follows the philosophy behind the English Weighted Capitation formula, the so-called utilisation approach (Department of Health, 2011, Dixon et al., 2011, Fadgyas-Freyler 2018) illustrated by the following figure:



The utilisation approach, role of need and supply (from DH, 2011)

Contrary to normative methods, this model is based on the utilisation of the health care system itself. It aims to estimate the health need of the individual though this cannot be directly observed. The basic idea of the system is that demand (experienced via utilisation) is stimulated both by the supply and the need. Though it is true that need cannot be directly observed, but it surely correlates with health status and socio-economic factors of the patient. It can be derived from the utilisation by controlling for the effect of supply.

Components of the empirical model

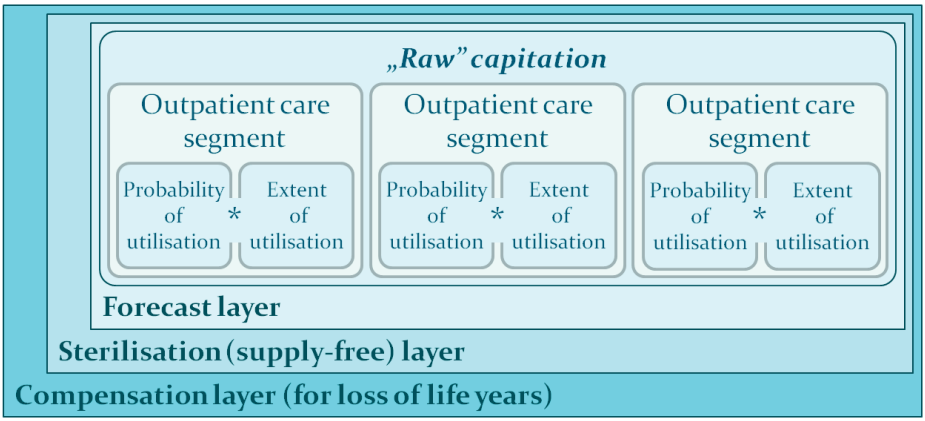
The empirical model applied to the Hungarian system is a combination of the matrix and the index method. For setting the matrix following personal characteristics of the individual were used: age group, source of entitlement (legal status) and occupational status (whether or not a person had a tax declaration, therefore social contribution was paid to the National Tax Authority). There are around 130 legal titles (sources of entitlement) in Hungary to gain access to health care which we have grouped into six groups. These groups were: 1. persons without entitlement 2. contribution payers, 3. persons with entitlement due to disability, 4. entitlement for socially disadvantaged groups, 5. other source of entitlement (youngsters, pensioners, etc.)

With the help of the characteristics listed the entire population of 9.6 million persons has been grouped into 63 different cells so that within the cells

- the standard deviation of the spending decreases compared to the deviation in the whole population and
- observed personal characteristics (e.g. deprivation index) have a linear effect on the spending.

In case the cell did not have at least one thousand persons, it merged into another one with similar characteristics cells.

The three layers of the capitation model can be illustrated with the following figure:



Layers of the model

Forecast layer

The first layer ('raw capitation') is the forecast layer predicting future health spending of the person based on his/her characteristics.

Several statistical models were tried for the elaboration of the first layer, the final one is a so called two stage model. By this in the first step the probability of health care utilisation has been estimated with a multivariable probit regression based on the personal characteristics. In the second stage – for those individuals who actually did use health services – the extent of health spending has been estimated in the same manner (multivariable linear regression). The final model has used only the significant variables in each cell, so that the most performing ones have remained - obviously they differ from cell to cell, segment to segment. Through the multiplication of those two numbers (probability of utilisation*extent of utilisation) the amount of capitation for each individual in the given segment can be obtained, consequently for everyone, independently from former utilisation.

The model has been run without any further transformation or truncation of the costs, though the costs of certain extremely extensive diseases (haemophilia, etc) have been not considered in the model. The regressions have run independently on three

segments of the model, such as outpatient specialist care, inpatient specialist care and prescribing.

Finally the capitation fee for each individual has been summed up from the three different segments so that each individual has got one capitation fee.

Supply-free (sterilization) layer

The second layer has modified the previously obtained "raw" capitation fee so that the values of the supply variables have been replaced with the national average, thus eliminating the effect of supply characteristics. This method of sterilisation follows the English methodology.

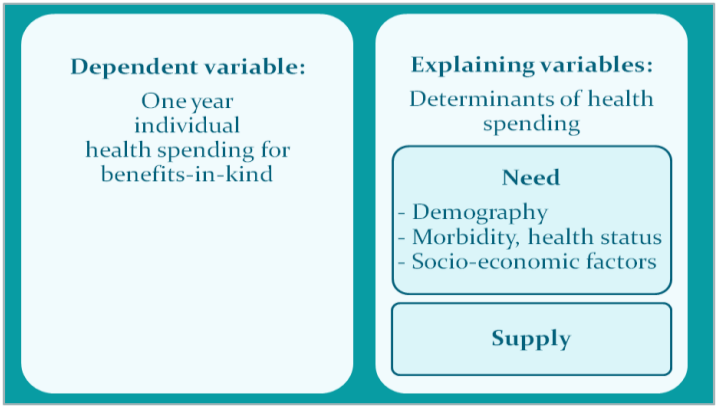
Compensation layer (for loss of life years)

The idea for the third layer is also used in the English resource allocation system (DFLE or former HI formula). It takes into account the forecasted life year loss of an individual, for the life expectancy and disability-free life expectancy respectively. For this each individual capitation fee has been reduced be 1/10 by a multiplication of the capitation fee by 0,9. Therefore one tenth of the budget has become available. This sum has been divided by the potential life years lost for the whole population (comparing each individual's life expectation to the best performing regions in Hungary) so that a compensation fee for each lost year has been created. After that every person has been given an extra compensation fee according to the life-loss expectancy at his/her place of residence.

The three layers of the model thus created allow us to assess the real health need of each individual and gives us the risk-adjusted capitation fee according to his/her characteristics.

Variables of the model

The model contains all variables of health determinants for which appropriate data were available or obtainable in the country. These variables can be grouped according to the categories of the usual linear regression models as follows:



Structure of the model

The dependent variable of the model is the one-year health expenditure of a given individual (2015) for benefits-in-kind. Independent (explaining) variables are all the factors attributable to the individual that may affect health spending. Among these we can distinguish between need variables and supply variables. The first group contains (a) demographic variables including age, gender and marital status; (b) morbidity and clinical variables such as prevalence of certain chronic diseases (Diabetes, COPD, hypertension or IHD), end-of-life status, previous (t-1, t-2) high spending; (c) socio-economic factors such as deprivation of residence, size of settlement, source of entitlement, holder of social access card, income and educational level.

The second group included so-called supply variables like travelling time to providers, GP availability, age of GP, inpatient and outpatient capacities in the county of residence.

RESULTS

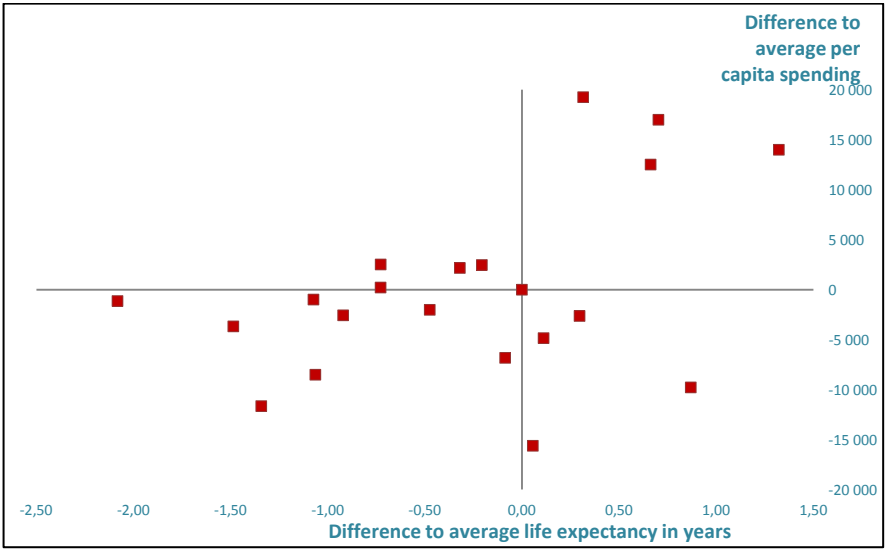
The work done has brought significant new scientific results from both methodological and health policy aspects.

New Results - From a Health Policy Point of View

The dissertation proved the possibility that capitations calculated with the new methodology could lead to a resource allocation based on need assessment. As a consequence budgets could be allocated in a normative manner.

Another important result for Hungarian health policy is the availability of a detailed, analytic presentation of the capitation system of three European countries.

The next figure shows together the actual per capita spending in 2015 (vertical axis) and the difference of a given county in LE (horizontal axis) compared to the country average (weighted by population measures) as a measure of health status.



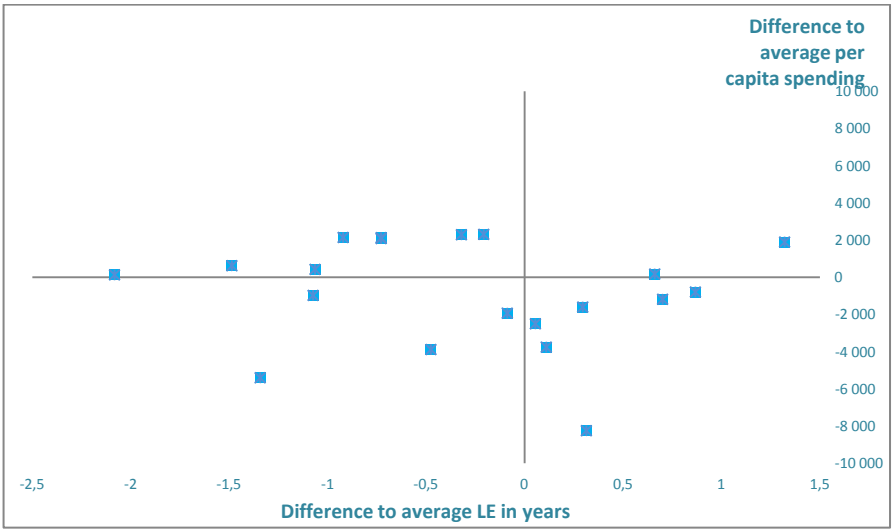
Difference to average LE and actual per capita spending (2015) by county, starting point

The axes divide the space into four parts: in the upper right corner we find those counties, whose LE is better that the average and at the same time health spending is

also higher than the average. In this part there are all four university counties one of which is the capital. In the lower right corner, we will find counties with better health status and smaller health spending that the average. In the lower left corner we can see the counties where life expectancy is shorter than the national average, but this is not reflected in their health spending because it is below the national average. In same cases worse health status (minus two year) goes hand in hand with average per capita spending. In the top left corner shorter LE is combined with higher spending. There aren't really any counties in the upper left corner where shorter life expectancy would be combined with higher spending.

The fact that in Hungary more resources flow into regions with better health status has been like that for decades. This phenomenon indicates a reverse resource allocation which would require action from the policy makers. As an effective allocation, it would be desirable to direct more money in those areas with higher need measured by life expectancy. The aim of the dissertation was to design a resource allocation model that would be able to mitigate disparity in life expectancy (vertical axis) due to more efficient resource allocation. Therefore, as a consequence of the work, we can expect on the figure more counties in the upper left corner (regions with shorter life span would receive more money) and less counties in the upper right corner, because regions with already better life expectancy would receive less money than under the current resource allocation. As ultimate goal we want the regions to move closer to the vertical axis as differences in health status diminish.

The next chart shows the result of the new resource allocation that is based on the new methodology of the dissertation. The county (NUTS3) capitations aggregated from the individual capitations with the two stage method are shown in the following figure:



Difference to average LE and average capitation by county, calculated with the new methodology

Again, the horizontal axis shows the difference of a given county in LE compared to the country average (this obviously has not changed yet). The vertical axis represents the difference of the calculated capitation fee to the average spending.

As a result of the new allocation method differences in the per capita spending have been reduced because all counties moved closer to the horizontal axis. Additionally the chart clearly reflects our expectation because it turned the 'perverse' left bottom to the right up direction into a more equitable left up to right down vector. This means that with the new allocation methodology we are able to direct more money to areas with worse health status (higher risk) and areas with better LE (lower risk) would receive less funding. Our allocation methodology therefore fulfils the criteria of a more equitable and more effective risk-adjusted capitation.

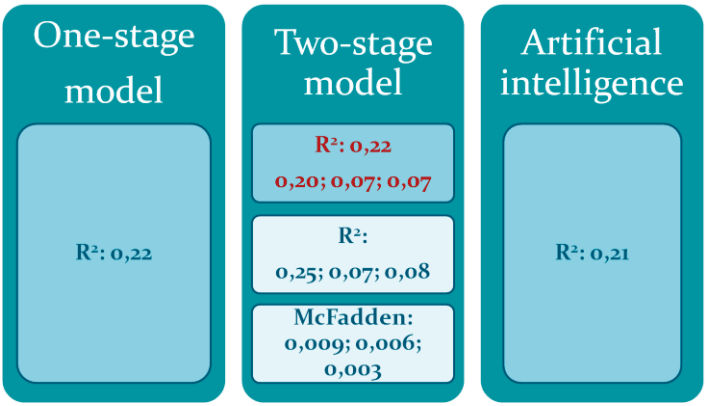
New results - from a methodological aspect

Following results can be listed here:

1. With exhaustive and meticulous work (data mining in its original meaning) a database has been created for 9.7 million persons that can be used for different analyses and the calculation of a risk-adjusted capitation formula.

2. During this experimental work five capitation models were developed for the production of the 'raw capitation'. This means that for each person a capitation fee has been calculated in five different ways. With the 2.1. one-stage model health spending was left without any transformation in its original form. In the two-stage models first we estimated the probability of utilisation (probit) and in the next stage the extent of estimated spending was calculated. The spending for the two stage approach could either stay in its 2.2. original form, or was used after a 2.3. logarithmic transformation. In the third type of the two-stage model a 2.4. Generic Linear Model (GLM) was used for the calculation of the spending. For model 2.5 artificial intelligence (random forest) was used, but only for a certain proportion of the population about which information with regard occupational status was available.

   The different models with the usual performance indicator of R^2 had following results:



Performance of the models

   Three of the models have been fully completed (indicated by darker green squares in the figure), others (with the lighter colour) have been run only of the level of the three segments (outpatient, inpatient, prescribing). The two-stage model with the logarithmic transformation has not been finished due to the difficulties with

the Jensen inequality. The GLM model has performed so badly that we ceased using it.

Therefore model-level performance indicators are only included for the three models. Results are similar with an R^2 slightly above 0,2. This are quite promising results, keeping in mind the performance of international capitation systems.

3. At the same time it has been proved that the combination of cell and matrix systems can lead to numerous problems. Originally we hoped that the effect of different variables could be better handled with this method. With quite acceptable model performance (R^2 around 0,2) we found negative capitation value on the individual level. This was caused both by using the costs without truncation and by the high number of persons without any utilisation. Due to these two factors the regression line crossed the vertical axis below zero. As a consequence we have concluded that models should not only be judged mechanically with the performance indicators. Instead they should be carefully evaluated also from the viewpoint of policy goals set by policy makers.
4. The negative capitation values calculated with the one-stage model showed the shortcomings of this method and guided our attention to the issue of missing utilisation. In order to handle this problem other methods have been investigated.
5. Each one of the selected explanatory variables proved to be significantly influencing health utilisation, the correlation matrices gave meaningful insight into their interference. In some cells R^2 was much higher that the average 0,2 so we can be sure about a successful selection of the variables.
6. As an advantage of the matrix method we have succeeded to cluster the population into more homogeneous groups with regard to utilisation patterns, spending and general characteristics. All three criteria of cell formation such as (1) age, (2) source of entitlement as a proxy for socio-economic situation and (3) existence of tax declaration as hint for occupational status proved to be very relevant. The evidence of their correlation with spending is an absolute novelty in Hungary.

7. Through the analysis of health utilisation habits of the population (comparison of distances between official address and temporary address or GP office, number of GP visits, number of specialist visits, number of hospital visits and number of pharmacy visits) it has become obvious that a significant number of people do not live at their official residence. In the model persons they have been assigned to their actual, real place of dwelling. If a new place of residence was chosen this was done either to the temporary residence or to the place where the GP office was situated. In this context it has also been proved that travelling distance to providers has a significant impact on health utilisation, though the willingness to travel and utilisation habits vary greatly between different age groups.
8. We have identified so-called “expensive diseases” causing the highest spending in individuals. As agreed internationally those costs are not easily handled within a capitation system therefore we excluded them from the model. With this exclusion the deviation of the spending decreased significantly and the maximum per capita spending decreased from 918 thousand Euro to 218 thousand Euro/person with an average spending of 350 Euro per person.
9. The variable of settlement size was finally omitted from the model because it had significantly redundant information with the variable of settlement deprivation. It has been proved that both demand and supply variables have a significant impact on spending. The strongest correlation with spending among the need indicators had previous year's spending, end-of-life status, morbidity indicators and holder of social access card. The correlation with the deprivation index is very strong in every single cell, but in several other cells also other indicators have proved to have significant impact on health spending, such as the tax declaration indicator as the proxy of employment, social contribution payment as proxy for income and we also have to mention educational level and family status. The supply indicators investigated (travelling time, capacity and vacant general practitioner offices) also had significant impact on health spending, among them the most important one was travelling time.

10. The results of the dissertation have clearly demonstrated the usefulness and suitability of administrative data sources for the calculation of capitation fees.
11. The calculations have also revealed the necessity of a strong hardware and other IT equipment. Even with the IT capacities available by the Health Insurance Fund we can report extreme long times for the queries. We have encountered limitations of IT capacity while running random forest so that the size learning population had to be kept relatively small (approx 0.2 million versus 4.6 million). Greater learning population would presumably overperform other methods.
12. With the aggregation of the capitations fees to different regional levels (NUTS 4 and NUTS5) it has been proved that the volatility of the effects reduces with growing aggregation size.
13. The capitation fee calculated with the three layers of the new methodology differs significantly from the present resource allocation. By adjusting the capitation fee with the sterilisation (control of supply effects) and the loss of life years we could show that the new capitation allows a more equitable and efficient resource allocation for it follows the health need of the population.

FURTHER PERSPECTIVES

The presented methodology and the documentation of the work has demonstrated that the elaboration of a new capitation methodology requires longer time and interdisciplinary collaboration.

While developing the capitation methodology following questions also have to be considered: The most important question is what are the goals of the new resource allocation formula? In what kind of institutional settings would it be used? What other instruments (risk-sharing, etc.) could be used additionally to the new formula? What would be the effect of the new resource allocation formula on the single risk-pool of the Hungarian population? How would it affect the free choice of doctors? Would the money follow the patient? If yes, what mechanisms are needed for the payments between different organisations receiving the capitations? What tasks and what type of

authorities would they be given? What would be the preferable size for the risk-pools? Who would be responsible for the capitation methodology and what would this organisation be allowed to do in order to minimize its potential shortcomings?

The models developed offer lot of opportunities for further work. The database can be used for analyzing the effects of the various variables, etc. Longitudinal analysis can be done in case the data are updated regularly. As far as the further technical development of the formula is concerned we suggest the use of further morbidity groups. It has also become clear that data currently only available in the tax declarations (persons with employments) can have a significant impact on the prediction capacity of the model.

For other determinants of health utilisation are also well known, it would be extremely useful to include into the model some data on health behaviour or clinical data that are currently not available. Due to higher OOP spending in Hungary it would be also extremely helpful if the organisation responsible for the capitation formula had information about health utilisation in the private health sector.

The German, Dutch and English experience also demonstrates that the introduction of a new resource allocation methodology should not happen without the establishment of a proper institutional framework responsible for the development of the capitation method and assessment of the experiences with it, because the monitoring and continuous work with the formula requires long-term commitment from the policy makers. The impacts and possible shortcomings of capitation can be only corrected by an independent and well established institution with appropriate means and well defined responsibilities.

The technical modelling of the capitation is only a part of the work that needs to be accomplished towards a more equitable and more efficient health resource allocation in Hungary. The author hopes that this dissertation can contribute to it.

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