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APPLYING THE PRIORITY DISTRIBUTION METHOD FOR EMPLOYEE MOTIVATION

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Abstract. In an age of increasing healthcare expenditure, the efficiency of healthcare services is a burning issue. This paper deals with the creation of a performance-related remuneration system, which would meet requirements for efficiency and sustainable quality. In real world scenarios, it is difficult to create an objective and transparent employee performance evaluation model dealing with both qualitative and quantitative criteria. To achieve these goals, the use of decision support methods is suggested and analysed. The systematic approach of practical application of the Priority Distribution Method to healthcare provider organisations is created and described.

Keywords: remuneration scheme, performance-related pay, pairwise comparison method, healthcare provider organisations, decision support methods, data mining application.

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1. Introduction

This article addresses the issue regarding the use of a financial employee motivation model based on measured performance and individual value-added in the healthcare sector.

An overview of early and contemporary theories of motivation factors shows that depending on the way it is used, motivation can influence internal characteristics and external behaviours of employees and affect their performance (Abramson, Inglehart 1995; Martinkus, Savanevičienė 1996). It should be noted that many forms of motivation exist and not all of them lead to the same results. The choice of motivation instruments depends on industry, company policies, employee job profile characteristics and other factors. In each organisation, its remuneration system forms the foundation of a multi-layered motivational system. Besides, it must be fair, equitable, consistent and transparent. In addition, performance-related pay must be based on accomplishments of an individual employee or joint results of the team, provided efforts of separate employees are impossible to measure.

Performance or work output based employee motivation systems are used in many domains. The prerequisite for performance-related remuneration is the ability to define regularly measurable work results and their qualitative parameters. By linking employee pay to individual and teamwork results, managers can use the remuneration system to promote high performance culture, teamwork and foster other organizational objectives.

The creation of a financial employee motivation model is a complex multi-level endeavour, which may influence business results of an organisation. By implementing a financial motivation system, organisations harness two competing interests: on the one hand, concerned with maximisation of their pay employees become interested in improving their work results; while on the other hand, the employer is interested in cost savings. Since ancient times, various remuneration systems have been created to ensure cost-effectiveness, employee motivation and social balance. The main remuneration system types are time-based (basic pay for standard hours) and unit-based, also called piece rate reward systems. Additionally, employers may use bonus systems such as additional hours reward, sales commission, and profit-related. Numerous variations and combinations are available depending on an industry or a job profile.

In terms of unit-based forms of remuneration schemes, employees have an incentive to increase labour productivity, which in turn leads to higher pay. In the healthcare domain, this type of payment is directly linked to the most popular reimbursement model, namely Pay-for-Service. It is heavily used by private healthcare provider organizations (HPO) worldwide, particularly in the US.

Indirect unit-based remuneration is characterised by indirect work results of an employee. In this instance, performance related pay of support staff is linked to achievements of the entire team; e.g. the variable salary portion of an operational theatre nurse may depend on the overall performance of the team.

However, in most public and some private HPOs, the financial model of an organisation is rarely transposed into the remuneration scheme; consequently, time-based remuneration is typically used. As European countries have a higher share of public HPOs, the most common form of payment is a time-based salary system, where amount paid is a function of hours worked and employee qualifications. The simplest time-based form of payment is the unified payment for work time system, which is a fixed basic pay for standard hours.

Employee qualification requirements and job profile complexity is perceived differently in different countries, industries and even competing companies. A set of defining criteria includes all factors affecting job characteristics and conditions. Such criteria set may include the required level of education, cooperation, concentration, universality and working conditions (Kahya 2007; Poggi 2010; Katsikea, Theodosiou, Perdikis, Kehagias 2011).

This paper provides an overview on regulation of labour relations through performance-related payment schemes, which aim to ensure cost-effectiveness, employee motivation and social balance. This significantly increases the importance of the human factor, with the focus on personal responsibility, operational efficiency and continuous improvement processes.

The practical implementation of performance-related payment models in an organisation has three steps: planning, implementation and monitoring of the new remuneration model.

The planning step consists of determination of performance indicators to be used in the model; creation of a calculation model for performance related pay; discussion and communication with personnel.

The implementation step consists of the actual implementation of new accountancy policies, performance measurements and changes to Human Resource (HR) policies.

The monitoring step is a routine activity aiming to monitor and analyse changes in an organisation caused by an implemented employee remuneration model.

This article covers planning, execution and monitoring steps, excluding the HR related activities associated with communication, legislation and financing. In the second section, the author analyses the current situation in the healthcare sector and the latest trends in remuneration models used. Based on the analysis, a multi-criteria decision support method is proposed for the design of a performance related remuneration model for HPOs. In the following sections, the article describes the Priority Distribution Method (PDM) and showcases its use by inpatient healthcare providers. Finally, it proposes methods for determination of performance indicators to be used in PDM, including decision support and data mining, as well as techniques for subsequent monitoring of achieved results.

The article offers an illustration on the use of described methods in healthcare provider organisations and evaluation of the value of each job profile, considering subjective and objective social factors, which affect the salary.

2. Remuneration scheme for medical professionals

Currently, a number of substantially different financial models are used in healthcare worldwide. Each of them proposes a different business model for healthcare providers. Nevertheless, fee-for-service, per capita payment and pay-for-performance are the most frequent major reimbursement methods.

Regardless of the financial model, a public or private insurance entity reimburses all legal medical services provided to a patient, provided they fall within insurance coverage. In some cases, healthcare organisations receive fixed payments for each patient registered with that particular service provider. Typical for primary care, this model is used in the UK, US, post-Soviet countries, etc. Pay-for-performance model is usually used by insurance agencies as a bonus, provided a healthcare facility meets certain quality and performance requirements.

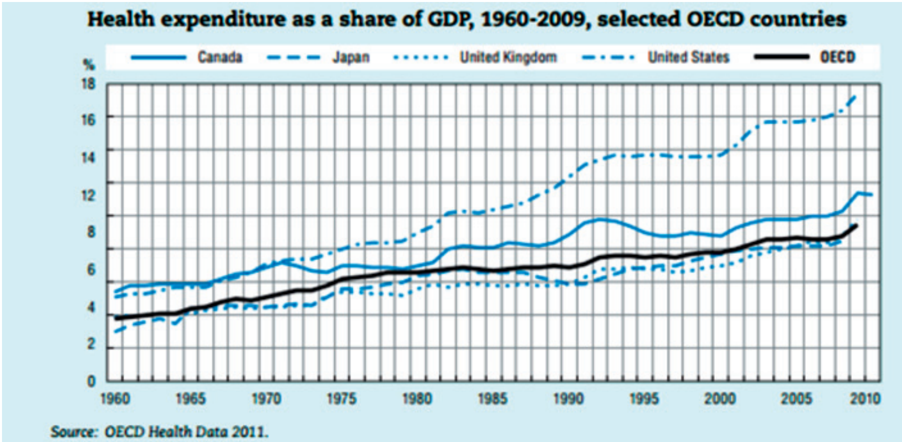

Fig. 1. Healthcare expenditure growth (Source: Health at a Glance 2011)

In the era of steady healthcare expenditure growth (Health at a Glance 2011), which is illustrated in Fig. 1, society demands better efficiency from healthcare providers. Thus, healthcare policy makers are looking for systematic changes that would result in better quality of services, more efficient healthcare providers and a healthier population for less money. This is a truly complicated challenge; however, some recent examples of different initiatives aimed at tackling chronic problems of healthcare systems do exist. For example, a new financial model for healthcare providers ACO (Accountable Care Organizations) has been recently introduced in the US. It aims to motivate providers financially by setting metrics for qualitative factors and overall performance. This model complements the "fee-for-service" model with a performance bonus based on quality and cost savings. Some European countries have introduced special programmes in order to encourage early detection and prevention of diseases such as diabetes, tuberculosis and HIS as well as breast, prostate and lung cancers. Different financial incentive systems are used to encourage healthcare providers to participate in these programs.

Getting better results from doctors and nurses requires active performance monitoring and management. Different contract types and bonus packages have been used to improve the quality of services provided by medical professionals. Payments based on the fee-for-service method have caused justified concerns regarding the delivery of medically necessary services and led to unjustified admissions as well as other problems (Lee, Mongan 2009). However, time-based salary does not lead to efficient work and encourages lower output. Most innovative healthcare providers introduce payment mechanisms that combine incentivised output and quality outcomes (Darves 2011). Examples are known where up to 20 per cent of doctor salaries are performance related, with nearly half being linked to team performance and quality improvement measurable values (Paulus *et al*. 2008). At top class HPO Kaiser Permanente, doctors are monitored and ranked in real time on a wide variety of clinical outcomes (Paulus *et al*. 2008). The monitoring data is immediately available, so doctors can compare their personal results with those of peers in their group or even across the region.

Not only doctors are subject to changes anticipated in the field of financial incentives. Nursing personnel is typically the most populous group of professionals in healthcare, and their contribution is an essential component to achieving improved productivity, better quality of care and higher effectiveness in the health sector (Buchan, Black 2011).

With regard to salaries of medical professionals, reimbursement methods used by HPOs have a different influence on remuneration schemes. Firstly, there are different financial motivators driven by these methods. Fee-for-service financially encourages high output of services provided to a patient, per capita payment financially rewards minimisation of services provided, while only pay-for-performance method seeks for long-term and high-quality results. Naturally, complex coexisting financial models result in a number of different models for remuneration of medical employees. However, in practice, two most popular payment forms persist, namely: time-based fixed salary in public HPOs and performance-related salaries in private healthcare facilities. The performance-related salary scheme is typically calculated considering quantitative results, e.g. number of patient visits, examinations, surgeries, etc.

In private HPOs, employee salaries are determined by the following main factors: amount of services provided; price level in the market; and personal contribution of an employee.

Different countries undergo continuous reform of their healthcare systems, and the determination of medical personnel remuneration scheme in public HPOs is one of the central issues.

In public HPOs, salaries of medical professionals are usually time-based and formally defined by the governing body. Obviously, this payment method alone does not provide adequate motivation for higher quality or performance. However, usually there are some possibilities to introduce bonuses or a performance-related payment method based on individual or teamwork results, which could be used as financial motivation instruments.

When an employee's contribution cannot be expressed in money or as a percentage of revenue, it is considered a subjective decision of the employer. In the public sector, the remuneration scheme is determined by the job evaluation system. The International Labour Organization has suggested a job evaluation system based on four general factors. Each factor has a certain maximum number of points, with the total amount of four factors equal to 1000 points. The maximum value of 450 points is assigned to the work complexity factor. Work complexity is seen as an aggregative factor of required professional education and experience, decision magnitude and managerial level. Social value of work can get the maximum of 220 points; it is determined by two criteria: appointment procedures and social significance of work. Professional responsibility has the maximum of 180 points; it is described by three criteria: impact on safety of other people, material and moral responsibility, and cooperation with external organisations. The last factor is work complexity and work environment, which can get the maximum of 150 points; it is characterised by two criteria: mental and physical stress, caused by the level of nervous strain at work and working conditions. According to this system, each job profile is rated according to the aforementioned four factors assigning points. Finally, totals are calculated and normalised, and the resulting coefficient is applied to the official minimum monthly salary.

Regardless of the ownership form of an HPO, and the reimbursement model of the healthcare institution, the introduction of a balanced performance-related payment scheme for medical professionals, which considers both qualitative and quantitative factors, may provide an answer to the current efficiency problems faced by the healthcare sector. Implementation of such balanced performance-related remuneration scheme requires determination of measurable indicators. There is a number of healthcare quality and performance indicators that are a part of best practice business metrics or governmental programs and legislation. However, there is a lack of methods for selection, ranking and weighting of these indicators, gathering them into one system suitable for financial employee performance evaluation. For this purpose, it is suggested to use the Priority Distribution Method, described by Žaptorius in 2006.

3. Selecting performance indicators

The change of the existing employee remuneration system of an organisation should start with determination of performance indicators to be used in a new model. Typically, the first point of reference would be the list of key performance indicators defined by the organisation itself. However, healthcare sector is usually influenced by external forces such as governmental bodies or insurance companies, which set financial incentives for meeting certain criteria. Therefore, depending on the healthcare facility profile and region, one can select from among different sources. One of them is the "Meaningful Use" program (Meaningful use 2013) established by the US Department of Health and Human Services, which has a set of criteria for organisations meaningfully using electronic health record systems. Another initiative from the US is called Accountable Care Organizations (ACOs), which proposes that participating healthcare facilities receive additional payments based upon specified quality and savings criteria. Another option is setting performance indicators for healthcare providers in legislation, as it is done in Lithuania by the Ministry of Health.

One can conclude that there is no lack of performance indicators for the healthcare industry; however, there is a lack of methodologies for the selection of optimal sets of indicators for a specific healthcare provider. There is a high magnitude of HPOs with different clinical domains and different financial schemes. Below, the author proposes a generic method, which allows an organisation to analyse and choose performance evaluation indicators for a performance-related remuneration model.

Step 1: Generate a comprehensive list of clinical, financial and managerial indicators, derived from the following sources: KPIs used internally, HPO performance related indicators assigned by insurance companies and HPO performance-related indicators assigned by government authorities.

Step 2: Filter indicators, which are practically measurable and applicable for calculation of financial incentives, and assign them to job profiles. Afterwards, they will be used to define the indicators' value scale, evaluation period and method.

Step 3: Transform interrelated indicators by combining them. For example, indicators such as overtime hours per month and number of night shifts per month can be combined into a composite indicator – *higher compensated work hours per month*.

Step 4: Preliminarily prioritise the indicators (final ranking of indicators will be made using the Priority Distribution Method (PDM) method). The rule of thumb is to give a higher priority to indicators linked to the organization's strategy and to raise priority of indicators that have low performance values.

Step 5: Identify potentially dependable indicators, i.e. indicators that are definitely dependable from other measurable indicators, which were not selected for the financial incentives model. This can be achieved manually or by applying statistical regression analysis tools. A wide range of clinical, statistical and financial data available in IT systems of an organisation should be used. The data collected in hospital information systems (HIS) has a significant potential for these types of analyses.

Step 6: Identify any specific factors leading to unsatisfactory values of selected indicators. We propose to perform this kind of analysis applying data mining methods, such as association rules analysis based on data prepared in step 5.

Let's consider the following example: an association rules discovery algorithm was used for data collected from a provider's HIS. One of the rules showed with high confidence a longer average length of stay for patients diagnosed with hospital acquired pneumonia, which was developed after using extra corporeal lung support systems. Consequently, the management decided to introduce a specific performance indicator related to a careful following of the defined algorithm and used it for the responsible medical personnel in appropriate wards.

Step 7: Based on results obtained in step 6, update each performance criteria list in job profiles in each organisational unit.

Step 8: Use the PDM method to rank quantitative and qualitative criteria and calculate performance related pay.

Data mining methods can be helpful to determine other important indicators, which influence initially defined (primary) indicators.

The benefit of this type of analysis is automated intelligent analysis of the aggregated data from different domains:

- Patient demographics, clinical patient data;
- Illness scripts, including epidemiology and average prognosis;

– Computerised physician order entry systems (CPOE) data;
– Data collected from nursing charts;
– Surgery and minor interventions protocols;
– Medical personnel HR data.

For example, using classification trees (Bellazi, Zupan 2008; Berka, Rauch, Zighed 2009) we can determine what factors influence longer Length of Stay (LOS), higher mortality rate for specific nosology, or readmission rate. This approach is suitable for HPOs that have already implemented HIS and or Electronic Medical Record (EMR) and that are not lower than STAGE 4 according to HIMMS electronic medical record adoption model (Electronic Medical Record … 2013). Modern HIS, EMR and medical decision support systems are able to provide vast amounts of data and allow applying data mining techniques to discover hidden patterns and dependencies as well as facilitate route-cause analysis.

4. Priority distribution method

The PDM belongs to the family of multi-criteria decision support methods, based on expert pairwise comparison of criteria.

In 1977, Saaty proposed a multi-criteria decision support methodology called the Analytic Hierarchy Process (AHP) to rank alternatives by pairwise comparison. This method requires evaluating the number of times one alternative (criterion) is better than another one. There are other applicable methods for this task as well: Simple Additive Weighting, TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), to name a few. Each has its pros and cons; however, high practical applicability is the strongest feature of the proposed PDM and the reason it was selected.

The weakest part of most pairwise comparison methods is the difficulty of normalising the expert opinions. For instance, defining the number of times mortality rate in a ward is more important than patient acquired post-surgery complication is very complicated even for a domain expert. Therefore, it is very helpful to reduce the comparison result range just to three categorical values as proposed in PDM, namely, less important, equally important, more important.

The downside of PDM is that the method is not mathematically precise. For a mathematically proven method, the author recommends a modified AHP version, which addresses the rank reversal problem.

According to Žaptorius (2006), the application of the Priority Distribution Method (PDM) to the financial portion of an employee remuneration package is possible under the following conditions:

– employees are working in teams or shifts and have similar job profiles,
– a variable salary part or performance bonus are applicable,
– it is impossible to directly and precisely evaluate the productivity of employees.

PDM is based on expert evaluation of qualitative and quantitative features of an object, i.e. one job profile compared to another one. The method allows evaluating objects, which have incomplete or only qualitative differentiation parameters. In practical settings, a panel of experts should be formed to analyse initial data and define comparison criterion for objects under investigation.

The method prioritises a group of objects in ascending or descending order, depending on the magnitude of their characteristics manifestation, thus calculating their ranks. Using pairwise comparisons, the relative importance of one criterion over another can be calculated.

Accordingly, for each object PDM defines relative weighting, which expresses the rank of each object's characteristics and helps to select and prioritise the criteria. PDM is flexible in adjustment of precision and degree of justification required for management tasks and optimal decision support.

Typically, when indicators with different origin and measurement units exist, the problem arises regarding normalisation and conversion to a unified measurement unit or non-dimensional unit. To tackle this problem, the method proposes the conversion of indicator values to their relational values (ratios), which are expressed in uniform, quantitative and therefore arithmetically comparable units. The initial step is to define the most important differentiating criteria, which will be used to calculate performance related payments. There is a number of possibilities for the selection of criteria, e.g. contracting external HR consultants, surveying employees and defining the number of votes, or basing definition on an individually generated value-added aligned with the company's business goals and key performance indicators. As indicated in the section "Selecting performance indicators", there is a set of typical indicators used in healthcare, some of which can be successfully projected to job evaluation indicators of an individual employee. These specific healthcare criteria are discussed in the next section.

There are two potential classes of criteria for evaluation of productive input of an employee: quantitative and qualitative. Criteria will be assumed as quantitative if they are measurable, numerical and their measurement or evaluation is not dependent on subject-matter expert opinion, e.g. number of patient visits, hospital length of stay, percentage of postoperative complications, and percentage of patient readmissions. In contrast, a qualitative criterion usually has categorical values that are indirectly evaluated by subject-matter experts, e.g. teamwork, discipline, loyalty, creativity, or proactivity. Such a qualitative criterion can be valued, compared to the etalon value if it exists, or compared to the respective criterion of other employees in the group or region.

According to the pairwise decision rule formulated by Terstown (Beshelev, Gurvich 1974), if a pairwise comparison is performed by a group more or equal to 25 independent experts then their evaluation values have a normal distribution with variance equal to one. In a practical setting, the typical number of experts is less than 25; consequently, distribution is close to normal.

Let us define the most important criteria set as K{k_1, k_2, k_3, k_4, k_5}. Each criterion k_n should have a defined value range, source, and calculation method.

To rank the criteria we need to define weight w_n of each criterion. In the frame of PDM, it is achieved by comparing criteria in pairs. In order to mutually compare k_n we will use the following table of all possible pairwise comparisons:

Table 1. Comparison of all possible criterion pairs

Criteria pair	Experts					Average priority value P^
	1	2	3	4	5	
w1 & w2	>	>	>	>	>	>
w1 & w3	>	>	=	>	>	>
w1 & w4	>	=	>	<	>	>
w1 & w5	>	>	>	>	>	>
w2 & w3	<	<	>	=	<	<
w2 & w4	=	=	=	>	<	=
w2 & w5	<	>	<	<	<	<
w3 & w4	>	>	>	>	=	>
w3 & w5	>	=	=	=	=	=
w4 & w5	>	=	>	>	=	>

(Source: created by the author)

All possible ratios of criteria pair comparisons are defined by the experts. This example analyses simplified and more practical comparisons, where the only ratio values that can be assigned by the experts are: greater than “>”, equal to “=”, or less than “<”, assuming that the same degree of relative difference of criteria pairs applies. Then, the comparison matrix $A = \|a_{i,j}\|$ is derived by using average priority values P^, and criteria conditional priorities P_{ij}^{S} are incrementally calculated. ||A|| is a square matrix with the size equal to the number of criteria *l*. As in many multi-criteria decision making methods that use pairwise comparison (Saaty 1977; Uppuluri 1989; Wilson, Thabane, Holbrook 2003), the matrix ||A|| is naturally reciprocal, where $a_{ij} = a_{ji}^{-1}$. Therefore, only the upper or lower part of it will be calculated, and another is easily derived.

PDM uses formula $a_{i,j} + a_{j,i} = 2$, with (1)

$$a_{i,j} \in [0;2].$$

According to PDM, the following heuristic is used to derive the comparison matrix.

$$a(x) = \begin{cases} 1+z, \text{when } x_i > x_j, \\ 1, \quad \text{when } x_i = x_j, \\ 1-z, \text{when } x_i < x_j, \end{cases} \qquad (2)$$

where **z** is defined as:

$$z = \frac{K_r - 1}{K_r + 1} + \sqrt{\frac{0.05}{l}}, \qquad (3)$$

where:

l – number of criteria,

and K_r – preliminary estimated maximum and minimum criterion weight ratio:

$$K_r = \frac{X_i^{\max}}{X_j^{\min}}, \qquad (4)$$

where x_i^{max} and x_j^{min} – compared *i* and *j* indicators with a maximum and minimum value.

By ranking expert ratios values (Table 1), $K_r=4$ can be estimated. Given the above estimated $K_{r,}$:

$$z = \frac{4-1}{4+1} + \sqrt{\frac{0.05}{5}} = 0.7 \qquad (5)$$

and

$$a_{i,j} = \begin{cases} 1.7, \text{when } x_i > x_j, \\ 1, \text{ when } x_i = x_j, \\ 0.3, \text{when } x_i < x_j. \end{cases} \qquad (6)$$

This derives a comparison priority matrix ||A|| as follows:

Table 2. Criteria weight comparison matrix

i \ j	w_1	w_2	w_3	w_4	w_5	$\sum a_{i,j} = b_i$	P_i	$P_i^{'}$
w_1	1	1.7	1.7	1.7	1.7	7.8	37.04	0.348
w_2	0.3	1	1.7	1	1.7	5.7	23.60	0.222
w_3	0.3	0.3	1	0.3	1.7	3.6	13.10	0.123
w_4	0.3	1	1.7	1	1.7	5.7	23.60	0.222
w_5	0.3	0.3	0.3	0.3	1	2.2	9.04	0.085
Sum:							106.38	1.000

(Source: created by the author)

Considering the matrix above, the criteria priorities P_i *and then* subsequently normalising $P_{i\,,}$ P'_i has been derived.

The calculation is provided below:

1. Calculate priority sums for each row:

$$\sum_{j=1}^{l} a_{i,j} = b_i .$$

2. Calculate P_i by summing the product of row priority $a_{i,k}$ and b_k:

$$P_i = \sum_{k=1}^{l} a_{ik} \times b_k . \tag{7}$$

3. Normalise conditional priorities P'_i values, dividing P_i by $\sum_{i=1}^{l} P_i$:

$$P'_i = \frac{P_i}{\sum_{i=1}^{l} P_i} . \tag{8}$$

With calculated P'_i values, actual K_r^f ratio is being calculated and compared to preliminary estimated ratio K_r:

$$K_r^f = \frac{P'^{\max}_i}{P'^{\min}_i} = \frac{0.348}{0.085} = 4.094 . \tag{9}$$

Thus, $K_r^f \neq K_r$, and we have to align the initially calculated z value.

The calculation of correction coefficient α:

$$\alpha = \frac{K_r}{K_r^f} = \frac{4,000}{4,094} = 0,98 . \tag{10}$$

The Aligned z value:

$$z = z_p \times \alpha , \tag{11}$$

where z_p – initial z value. Thus,

$$z = 0.7 \times 0.98 = 0.69.$$

Considering the new z value, a new a_{ij} valued has been derived:

$$a_{i,j} = \begin{cases} 1.69, \text{when } \mathrm{x_i} > \mathrm{x_j}, \\ 1, \quad \text{when } \mathrm{x_i} = \mathrm{x_j}, \\ 0.31, \text{when } \mathrm{x_i} < \mathrm{x_j}. \end{cases} \tag{12}$$

The recalculated comparison priority matrix ||A|| is provided below:

Table 3. Recalculated criteria weight comparison matrix

i \ j	w_1	w_2	w_3	w_4	w_5	$\sum a_{i,j} = b_i$	P_i	$P_i^{'}$
w_1	1	1.69	1.69	1.69	1.69	7.8	36.90	0.345
w_2	0.31	1	1.69	1	1.69	5.7	23.60	0.222
w_3	0.31	0.31	1	0.31	1.69	3.6	13.34	0.125
w_4	0.31	1	1.69	1	1.69	5.7	23.69	0.222
w_5	0.31	0.31	0.31	0.31	1	2.2	9.30	0.087
Sum:							106.91	1.000

(Source: created by the author)

In the resulting matrix (Table 3), weighted criteria ranks are expressed as normalised numeric weights P'_i.

The next step is to evaluate employees individually. Quantitative criteria evaluation can be directly performed, applying normalised measurement ranges. Individual employee criteria ranking will have the biggest weight value for the best performance value, accordingly, as the biggest weight value for the most important criterion was calculated in ||A||. Therefore, if a minimizing criterion exists, its value will be converted as follows:

$\bar{c} = \frac{\min c}{c_i}$, where $\min \bar{c}$ – the smallest value of an object's criterion.

This transformation of minimising criteria values will convert the smallest value to the largest equal to 1.

For individual employee's qualitative criteria evaluation, PDM will be applied. External experts or a team of employees should evaluate each employee pairwise, according to the steps described above. The results of the evaluation should be combined with the PDM results of criteria ranking. The complex employee performance value indicator $P_{i,compl.}$ is calculated as follows:

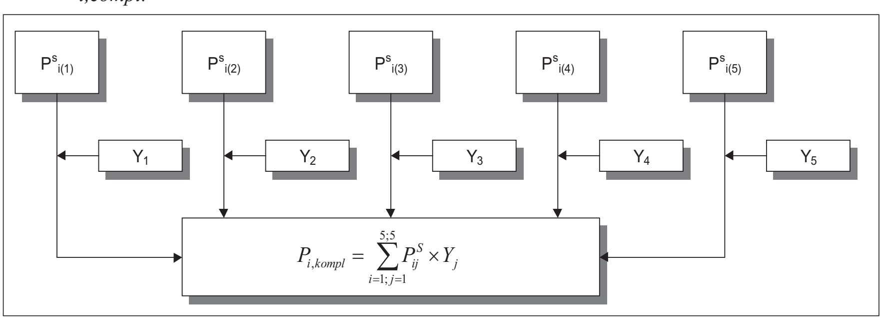

Fig. 2. Complex employee performance value indicator (Source: created by the author)

where $P_{i,compl.}$ – i-th employee performance value indicator, $P^{S}_{i(j)}$ – i-th employee evaluation weight for j-th criterion, y_j – j-th criterion weight.

The employee performance related payment is calculated using the fixed part of the salary, called the Base. Typically, the variable part of the salary is formed as a specific percentage K% of the Base, as defined by company policies. Applying the calculated complex employee performance value indicator (Fig. 2), the variable salary part equals to:

$$Salary_{\mathrm{var},i} = Salary_{fix.i} \times K \times PVI, \tag{13}$$

where

Salary$_{var,i}$ – the variable part of *i*-th employee salary (performance related pay);

$Salary_{fix,i}$ – the fixed part of the *i*-th employee salary.

According to Žaptorius (2006), this method can also be used as a method for evaluation of an employee job profile. From the point of view of HR management, this heuristic method expresses a comparative view of the market value of the job performed by certain employees.

The most practical outcome of the PDM is the definition of criteria weights for employee evaluation, which can be universally used in the frame of the analysed company/department/team.

5. PDM application in healthcare inpatient facilities

This section will focus on creating a performance-related remuneration model for a hypothetical inpatient healthcare facility. PDM will be used to create a performance-related payment model for physicians and nurses of one hospital ward.

As it was already stated, the initial step of PDM is to define indicators, which will be used to evaluate the overall outcome of work. For the sake of this example, performance indicators for HPOs approved by the Ministry of Health (MOH) of the Republic of Lithuania in 2012 (Dėl asmens sveikatos priežiūros įstaigų… 2012) will be used, which are aimed at raising the overall treatment quality and becoming a strong complementary evaluation to the quantitative metrics of provided medical services. Some of them can be aggregated and successfully projected to performance evaluation indicators of an individual employee. To restrict different types of healthcare providers and their operation modes, the example will use indicators applicable to the general profile hospitals.

The following quantitative and qualitative indicators from the list of inpatient facility indicators (Dėl asmens sveikatos priežiūros įstaigų … 2012), were selected:

Table 4. Aggregated indicators for performance evaluation approved by MOH

Quantitative criteria	Qualitative criteria
− Average length of stay − Ratio of inpatient day surgery visits to overall inpatient visits (incl. surgery) − Mortality rate − Frequency of pressure sores in bedridden patients − Use of disinfectant liquids	− Level of patient satisfaction − Participation in internal training programs − Practiced hygiene level

(Source: created by the author)

Additionally, the following healthcare quality and key performance indicators will be added: postoperative complication rate; rehospitalisation rate; medical errors/claims.

Additionally, the following non-domain specific criteria will be added.

Table 5. Generic indicators measuring employee performance

Quantitative criteria	Qualitative criteria
− Work hours − Shift coefficient − Medical qualification coefficient − Experience coefficient − Number of non-compliance/audit issues − Number of claims	− Team work orientation − Help to colleagues − Discipline

(Source: created by the author)

Let's define the criteria sets for ward physicians and ward nurses combining both criteria lists. Job profile criteria for a *ward nurse* can be defined as follow:

Table 6. Performance evaluation indicators for a nurse

Code	Criteria	Description
k_1	Work hours x shift coefficient x medical qualification coefficient	Composite evaluation of workload, assuming different ratios for weekday and night shifts and formally acquired medical qualifications
k_2	Accumulative number of registered issues and claims per quarter	Number of internal issues or external claims during the ongoing quarter.
k_3	Teamwork ability (six months/annual)	Shares information with colleagues. Ready to help colleagues. Demonstrates positive attitude. Demonstrates problem solving abilities.
k_4	Personal discipline (six months/annual)	Physician or head nurse orders performed on time and corresponding to quality requirements. Documentation activities performed according to hospital rules.

End of Table 6

Code	Criteria	Description
k_5	Average quarterly length of stay to average LOS ratio	Quarterly average patient LOS compared to the national or regional normative average LOS for the ward specialisation.
k_6	Mortality rate to average mortality rate ratio	Average patient mortality rate for a period of six months or a year compared with the national or regional normative average mortality rate for the ward specialisation
k_7	Frequency of pressure sores in bedridden patients to average frequency ratio	Number of pressure sore incidents in patients for a period of six months of a year
k_8	Practiced hygiene level	Quarterly quality metric, according to a hospital standard (e.g. use of disinfectant liquids, hygiene quality checks)
k_9	Level of patient satisfaction	Quality metric defined and digitised using patient surveys for a period of six months or a year.
k_{10}	Participation in internal training programs	Annual quality metric defined as a percentage of participation in internal training programs or individual annual goals.

(Source: created by the author)

Job profile criteria for a *ward physician* can be defined as follow:

Table 7. Performance evaluation indicators for a ward physician

Code	Criteria	Description
k_1	Work hours x shift coefficient x medical qualification coefficient	Composite evaluation of workload, assuming different ratios for weekdays and night shifts and formally acquired medical qualifications
k_2	Accumulative number of registered issues and claims per quarter	Number of internal issues or external claims during the ongoing quarter.
k_3	Teamwork ability (six months/annual)	Shares information with colleagues. Ready to help colleagues. Demonstrates positive attitude. Demonstrates problem solving abilities.
k_4	Personal discipline (six months/annual)	Orders of superior performance in time and in quality. Documentation of activities performed according to hospital rules.
k_5	Average quarterly length of stay to average LOS ratio	Quarterly average patient LOS compared to the national or regional normative average LOS for the ward specialisation.
k_6	Mortality rate to average mortality rate ratio	Patients mortality rate for a period of six months or a year compared to the national or regional normative average mortality rate for the ward specialisation.
k_7	Rate of postoperative complications	Rate of postoperative complications for a period of six months or a year compared to the national or regional normative average rate for the ward specialisation.

End of Table 7

Code	Criteria	Description
k_8	Rehospitalisation rate	Average rehospitalisation rate for a period of six months of a year compared to the national or regional normative average rate for the ward specialisation.
k_9	Level of patient satisfaction	Quality metric defined and digitalised through patient surveys for a period of six months or a year.
k_{10}	Participation in internal training programs	Annual quality metric defined as a percentage of participation in internal training programs or annual individual goals.

(Source: created by the author)

Pairwise comparison as defined in PDM is used to rank and weigh the identified criteria. Below, an example of calculations is provided. These values will be recalculated for each healthcare institution, aiming to apply this method. As explained before, the nature of financing model used in each particular facility will strongly affect employee motivation. Therefore, the ranking and weight of the criteria defined will differ from one healthcare organization to another.

As the second PDM step, all defined criteria are compared in pairs by the expert panel. The resulting tables of criteria for physicians and nurses are provided below.

Table 8. Pairwise criteria comparison of ward nurses

Criteria			Average value	Criteria			Average value	Criteria			Average value
W_1	vs	W_2	>	W_2	vs	W_9	<	W_5	vs	W_6	<
W_1	vs	W_3	>	W_2	vs	W_{10}	>	W_5	vs	W_7	<
W_1	vs	W_4	>	W_3	vs	W_4	<	W_5	vs	W_8	<
W_1	vs	W_5	>	W_3	vs	W_5	<	W_5	vs	W_9	<
W_1	vs	W_6	>	W_3	vs	W_6	<	W_5	vs	W_{10}	<
W_1	vs	W_7	>	W_3	vs	W_7	>	W_6	vs	W_7	<
W_1	vs	W_8	>	W_3	vs	W_8	<	W_6	vs	W_8	>
W_1	vs	W_9	>	W_3	vs	W_9	<	W_6	vs	W_9	>
W_1	vs	W_{10}	>	W_3	vs	W_{10}	>	W_6	vs	W_{10}	<
W_2	vs	W_3	>	W_4	vs	W_5	>	W_7	vs	W_8	>
W_2	vs	W_4	<	W_4	vs	W_6	>	W_7	vs	W_9	<
W_2	vs	W_5	>	W_4	vs	W_7	>	W_7	vs	W_{10}	<
W_2	vs	W_6	<	W_4	vs	W_8	>	W_8	vs	W_9	>
W_2	vs	W_7	<	W_4	vs	W_9	<	W_8	vs	W_{10}	>
W_2	vs	W_8	<	W_4	vs	W_{10}	>	W_9	vs	W_{10}	>

(Source: created by the author)

Table 9. Pairwise criteria comparison of ward physicians

Criteria			Average value	Criteria			Average value	Criteria			Average value
W_1	vs	W_2	>	W_2	vs	W_9	<	W_5	vs	W_6	<
W_1	vs	W_3	>	W_2	vs	W_{10}	>	W_5	vs	W_7	<
W_1	vs	W_4	>	W_3	vs	W_4	<	W_5	vs	W_8	<
W_1	vs	W_5	>	W_3	vs	W_5	<	W_5	vs	W_9	<
W_1	vs	W_6	>	W_3	vs	W_6	<	W_5	vs	W_{10}	<
W_1	vs	W_7	>	W_3	vs	W_7	<	W_6	vs	W_7	>
W_1	vs	W_8	>	W_3	vs	W_8	<	W_6	vs	W_8	>
W_1	vs	W_9	>	W_3	vs	W_9	<	W_6	vs	W_9	>
W_1	vs	W_{10}	>	W_3	vs	W_{10}	>	W_6	vs	W_{10}	<
W_2	vs	W_3	>	W_4	vs	W_5	>	W_7	vs	W_8	<
W_2	vs	W_4	<	W_4	vs	W_6	>	W_7	vs	W_9	<
W_2	vs	W_5	>	W_4	vs	W_7	<	W_7	vs	W_{10}	>
W_2	vs	W_6	<	W_4	vs	W_8	<	W_8	vs	W_9	<
W_2	vs	W_7	<	W_4	vs	W_9	<	W_8	vs	W_{10}	>
W_2	vs	W_8	<	W_4	vs	W_{10}	>	W_9	vs	W_{10}	>

(Source: created by the author)

Using the results of pairwise comparison, the following priority matrixes with justifiable a_{ij} are derived:

Table 10. Initial priority matrix for evaluation of criteria weights of a ward nurse

j \ i	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	w_{10}	$\sum a_{i,j}=b_i$	P_i	P'i
w_1	1	1.404	1.404	1.404	1.404	1.404	1.404	1.404	1.404	1.404	13.6	135.59	0.1401
w_2	0.596	1.000	1.404	0.596	1.404	0.596	0.596	0.596	0.596	1.404	8.8	82.25	0.0850
w_3	0.596	0.429	1.000	0.596	0.596	0.596	1.404	0.596	0.596	1.404	7.8	76.31	0.0788
w_4	0.596	1.571	1.404	1.000	1.404	1.404	1.404	1.404	0.596	1.404	12.2	117.16	0.1210
w_5	0.596	0.429	1.571	0.429	1.000	0.596	0.596	0.596	0.596	0.596	7.0	66.85	0.0691
w_6	0.596	1.571	1.571	0.429	1.571	1.000	0.596	1.404	1.404	0.596	10.7	103.08	0.1065
w_7	0.596	1.571	0.429	0.429	1.571	1.571	1.000	1.404	0.596	0.596	9.8	94.77	0.0979
w_8	0.596	1.571	1.571	0.429	1.571	0.429	0.429	1.000	1.404	1.404	10.4	97.96	0.1012
w_9	0.596	1.571	1.571	1.571	1.571	0.429	1.571	0.429	1.000	1.404	11.7	112.34	0.1161
w_{10}	0.596	0.429	0.429	0.429	1.571	1.571	1.571	0.429	0.429	1	8.5	81.64	0.0843
Sum												967.96	1.0000

(Source: created by the author)

Table 11. Initial priority matrix for evaluation of criteria weights of a ward physician

j \ i	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	w_{10}	$\sum a_{i,j}=b_i$	P_i	P'i
w_1	1	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	1.571	15.1	147.74	0.1643
w_2	0.429	1	1.571	0.429	1.571	0.429	0.429	0.429	0.429	1.571	8.3	68.65	0.0764
w_3	0.429	0.329	1	0.429	0.429	0.429	0.429	0.429	0.429	1.571	5.9	52.98	0.0589
w_4	0.429	1.671	1.571	1	1.571	1.571	0.429	0.429	0.429	1.571	10.7	93.90	0.1044
w_5	0.429	0.329	1.671	0.329	1	0.429	0.429	0.429	0.429	0.429	5.9	51.55	0.0573
w_6	0.429	1.671	1.671	0.329	1.671	1	1.571	1.571	1.571	0.429	11.9	113.36	0.1261
w_7	0.429	1.671	1.671	1.671	1.671	0.329	1	0.429	0.429	1.571	10.9	93.65	0.1042
w_8	0.429	1.671	1.671	1.671	1.671	0.329	1.671	1	0.429	1.571	12.1	107.85	0.1200
w_9	0.429	1.671	1.671	1.671	1.671	0.329	1.671	0.329	1	1.571	12.0	106.59	0.1186
w_{10}	0.429	0.329	0.329	0.329	1.671	1.671	0.329	0.329	0.329	1	6.7	62.72	0.0698
Sum												898.99	1.0000

(Source: created by the author)

After the series of priority matrix perturbations described in PDM, K_r estimation error is minimised. Thus, when $K_r^f \neq K_r$, z value is adjusted multiplying it by correction coefficient α iteratively. After the series of initial matrix transformations, the following resulting priority matrixes are calculated:

Table 12. Resulting priority matrix for evaluation of criteria weights of a ward nurse

j \ i	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	w_{10}	$\sum a_{i,j}=b_i$	P_i	P'i
w_1	1	0.682	0.682	0.682	0.682	0.682	0.682	0.682	0.682	0.682	7.1	39.1	01389
w_2	0.289	1	0.682	0.289	0.682	0.289	0.289	0.289	0.289	0.682	4.8	24.1	0.0856
w_3	0.289	0.209	1	0.289	0.289	0.289	0.682	0.289	0.289	0.682	4.3	22.2	0.0788
w_4	0.289	0.763	0.682	1	0.682	0.682	0.682	0.682	0.289	0.682	6.4	34.0	0.1209
w_5	0.289	0.209	0.763	0.209	1	0.289	0.289	0.289	0.289	0.289	3.9	19.5	0.0695
w_6	0.289	0.763	0.763	0.209	0.763	1	0.289	0.682	0.682	0.289	5.7	29.9	0.1065
w_7	0.289	0.763	0.209	0.209	0.763	0.763	1	0.682	0.289	0.289	5.3	27.5	0.0978
w_8	0.289	0.763	0.763	0.209	0.763	0.209	0.209	1	0.682	0.682	5.6	28.6	0.1016
w_9	0.289	0.763	0.763	0.763	0.763	0.209	0.763	0.209	1	0.682	6.2	32.6	0.1160
w_{10}	0.289	0.209	0.209	0.209	0.763	0.763	0.763	0.209	0.209	1	4.6	23.7	0.0844
Sum												281.21	1.0000

(Source: created by the author)

Table 13. Resulting priority matrix for evaluation of criteria weights of a ward physician

j \ i	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	w_{10}	$\sum a_{i,j}=b_i$	P_i	P'i
w_1	1	5.590	5.590	5.590	5.590	5.590	5.590	5.590	5.590	5.590	51.3	1601.9	0.1662
w_2	1.528	1	5.590	1.528	5.590	1.528	1.528	1.528	1.528	5.590	26.9	725.0	0.0752
w_3	1.528	1.172	1	1.528	1.528	1.528	1.528	1.528	1.528	5.590	18.5	570.0	0.0591
w_4	1.528	5.946	5.590	1	5.590	5.590	1.528	1.528	1.528	5.590	35.4	1001.4	0.1039
w_5	1.528	1.172	5.946	1.172	1	1.528	1.528	1.528	1.528	1.528	18.5	551.8	0.0573
w_6	1.528	5.946	5.946	1.172	5.946	1	5.590	5.590	5.590	1.528	39.8	1225.3	0.1271
w_7	1.528	5.946	5.946	5.946	5.946	1.172	1	1.528	1.528	5.590	36.1	994.6	0.1032
w_8	1.528	5.946	5.946	5.946	5.946	1.172	5.946	1	1.528	5.590	40.5	1151.9	0.1195
w_9	1.528	5.946	5.946	5.946	5.946	1.172	5.946	1.172	1	5.590	40.2	1137.6	0.1180
w_{10}	1.528	1.172	1.172	1.172	5.946	5.946	1.172	1.172	1.172	1	21.5	678.0	0.0704
Sum												9637.67	1.0000

(Source: created by the author)

The normalised weight P'_i of each criterion is derived in the resulting matrices. When the criteria weights are defined, the next step is to evaluate each employee of the same position, i.e. a nurse or physician, by assigning measured values for each criterion. This can be done in a number of ways. In terms of quantitative indicators, this operation is mathematically trivial. However, in terms of qualitative criteria, different approaches exist. The formal evaluation is typically easier for hospitals where routine HR processes are established and all employees undergo regularly scheduled performance appraisal meetings. In other cases, it is suggested to use PDM to derive possibly more neutrally scored values of employee qualitative features.

The overall employee performance related value (PRV) calculation is based on derived criteria weights (Table 13) and measured or evaluated individual employee indicator values. The table used for ward nurses and physicians PRV calculation is provided below.

Table 14. Performance related value matrix for ward nurses and physicians

	Criteria rank weights and employee performance values									
Criterion weight value P_{-j} for nurses	0.14	0.09	0.08	0.12	0.07	0.11	0.10	0.10	0.12	0.08
Criterion weight value P_{-j} for physicians	0.17	0.08	0.06	0.10	0.06	0.13	0.10	0.12	0.12	0.07
Criterion value of an individual employee	p'_1	p'_2	p'_3	p'_4	p'_5	p'_6	p'_7	p'_8	p'_9	p'_{10}

(Source: created by the author)

The overall *i-th* employee value for *j-th* criterion equals to:

The employee performance-related value equals the sum of overall employee criterion values:

$$PRV_i = \sum_{k=1}^{j} p'_{ik} \times P'_k \text{ , where i-th - employee and j – number of criteria} \quad (14)$$

Applying the calculated employee performance related value, the variable salary part is calculated as follows:

$$Salary_{\text{var},i} = Salary_{fix.i} \times K \times PRV, \quad (15)$$

where

$\text{Salary}_{var,i}$ – the variable part of the *i*-th employee salary (performance-related pay);

$Salary_{fix,i}$ – the fixed part of the *i*-th employee salary.

6. Methods and tool sets for monitoring PDM efficiency

The described method for calculating performance-related payment of medical personnel is theoretical and needs practical approval. Therefore, it is essential to provide method and tools for evaluation of the PDM implementation outcomes. The change of financial personnel incentives may lead to a wide spectrum of implications, which in turn may influence organisation activities not covered by the metrics of the selected PDM indicators. Hence, we propose the methodology for monitoring and timely identification of PDM use effects on an HPO operation. The application of statistical analysis, pattern recognition, dimension reduction and other data mining methods allows to acquire more detailed information at early stages. Data mining can help determine if new patterns or associations come into force and how they evolve after the introduction of a new employee remuneration scheme.

The following systematic organisation performance monitoring and evaluation approach is suggested:

Activity 1: Collect and analyse the change of each criterion K over time (time series analyses)

Activity 2: Calculate the correlation coefficient to determine the influence of criterion weight to the measured values of PDM indicators.

Activity 3: Perform the direct association rules analyses, i.e. generate rules on acquired PDM indicator values and analyse the interdependent rules.

Activity 4: Perform a comprehensive association rules analyses, i.e. generate rules on all available indicators collected from an HPO medical information systems, e.g. HIS, EMR.

The first activity is most basic and shows direct results of PDM application. Different visualization methods will be applied for periodic analyses of change in indicators. Following the used case example, two visualizations of the values of criteria set's w_n

[$w_{1;}$ w_{10}] changes over a period of six months are provided below. Fig. 3 illustrates normalised measured criteria values. The normalisation was performed by rescaling values to [0; 1] scale and applying weight calculated by PDM. The minimised values were adjusted to its maximising values $\bar{c} = \frac{\min c}{c_i}$.

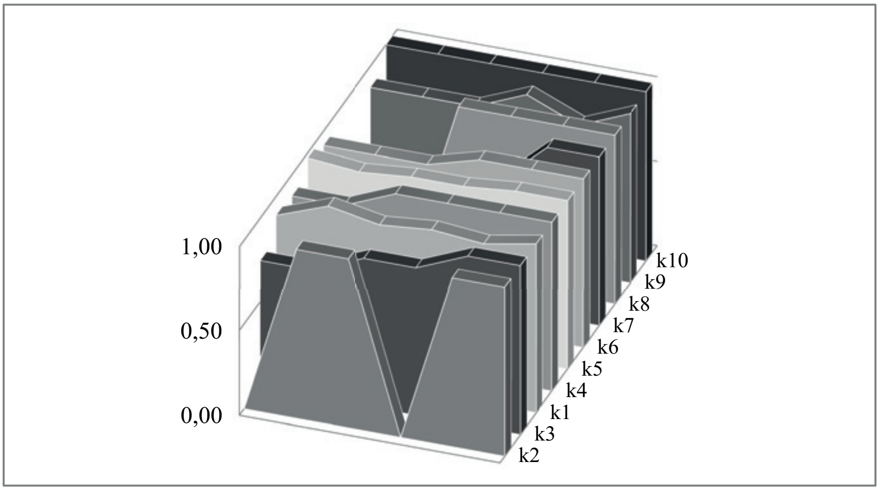

Fig. 3. The trend of PDM criteria values measured over six months
(Source: created by the author)

Fig. 4 represents the same trend applying dimension reduction. In this example, elementary reductions to criteria value sum and mean values were performed.

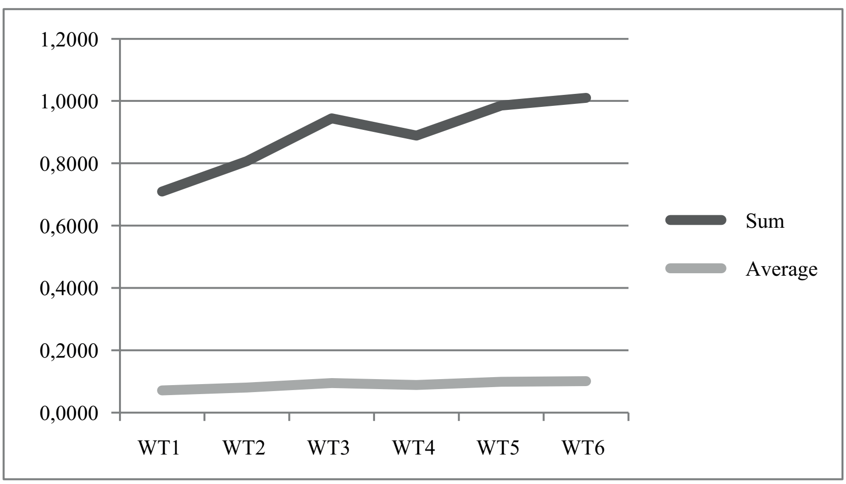

Fig. 4. The trend of descaled PDM criteria values over 6 months
(Source: created by the author)

The next recommended step is to formally calculate correlation R_n (second activity) of criterion K_n weight and averaged measured indicator value. Linear regression calculation may be used, which provides statistically well-defined evaluation criteria. Higher correlations coupled with higher variance of measured indicator values will show higher effect of the indicator weight in the applied PDM model.

Finally, deeper analyses for hidden effects may be applied by using association rules learning or inductive logic programming methods. Identified rules with higher confidence and smaller support values will identify non-obvious rules with higher correctness of the rule. Different existing algorithms can be applied to find association rules. Depending on the quality of the existing data, i.e. amount of missing data and noisy data, appropriate algorithms will be applied. According to multiple researches, the best results are achieved by performing data pre-processing, proper parameterisation and applying a set of different DM algorithms (Dzemyda, Kurasova, Medvedev 2007; Špečkauskienė, Lukoševičius 2009).

From the perspective of a system engineering, each organisation is a complex system interfacing with other external systems. Therefore, the information gained in activities 2–4 should be considered with care, by involving domain experts and analysing critically the causes of each change.

7. Conclusions

Healthcare policy makers and Healthcare Provider Organisations are in a constant battle with rising healthcare expenditure. There is a great need for innovative financial schemes, promoting greater effectiveness of services provided. A method utilizing multi-criteria decision support for the creation of a performance-related remuneration model in inpatient healthcare facilities was created.

The implementation of a well-balanced performance-related remuneration model needs a systematic approach. Having analysed the issues of practical implementation of performance-related pay schemes in the healthcare domain, a methodology consisting of performance indicator selection, use of the Priority Distribution Method and a method for monitoring its efficiency is proposed.

A pairwise criteria comparison method called the Priority Distribution Method was used for weighted personnel performance criteria ranking. Defining a personnel remuneration model for a HPO is a complex and manifold task, which highly influences overall enterprise results. In order to determine individual work outputs, healthcare providers have to use performance evaluation models. Recent global changes in the healthcare domain have resulted in a new understanding that a complex set of quantitative and qualitative criteria should be applied for the overall provider's activity evaluation. When projecting this perspective to the evaluation of individual performance, the issue arises regarding the qualitative criteria relative weight determination and its influence on overall employee performance, expressed in weighted criterion rank. PDM was specifically created to address these issues and provide a practically usable method, in which indirectly measured qualitative criteria are subjectively evaluated by experts (Žaptorius 2006).

Additionally, the issues of performance criteria selection for PDM and evaluation of PDM application results were discussed.

A method for healthcare specific criteria selection consists of six steps. The method emphases the use of well-defined criteria in healthcare legislation and healthcare sector best practices for setting the initial indicators. Specific indicators of an organisation can be derived from initial ones by way of applying intelligent data analysis techniques to available provider statistical, clinical and HR data. Use of association rules learning and other data mining methods can reveal additional non-obvious indicators, which can be included in PDM calculations.

To understand the applied PDM outcomes, the routine monitoring and recurring evaluation of individual and overall HPO performance is performed. The change of financial personnel incentives may also lead to unpredictable implications, which could influence provider's activities not covered by indicators selected for PDM. Therefore, four activities allowing direct and indirect evaluation of enterprise operation have been proposed. Data visualisation and dimension reduction techniques are useful for regular monitoring of criteria used in PDM. Criteria weight and measured criteria values change correlation analyses may be used for a more formal evaluation of weighted rank performance of the resulting criterion. Finally, data mining methods, i.e. association rules mining, and inductive logic programming may be used to discover hidden patterns.

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