Strategic Planning of Hospital Service Portfolios
The DRGee Viewer

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Abstract: In 2012 inpatient financing for hospitals in Switzerland was changed from a system based on cost per case to a system based on a fixed fee per case. The fixed-fee model makes medical services comparable from a financial point of view. Characterizing medical service portfolios in this way, creates large amounts of high-dimensional data. In order to operationalize this information and use it as a factual basis for decision support, we developed a visualization tool and a methodology to support strategic planning of hospital service portfolios. The method centers around a visual metaphor that provides the basis for strategic thinking. It is complemented by a visualization tool that allows visualization, analysis, and modification of service portfolios. Extensive support is provided for visual comparison of different scenarios. Special features enable the tool to be used during live planning sessions. The system was used in strategy workshops in over forty hospitals, and has contributed to infrastructure planning, reorganization, and resource optimization decisions.

1 INTRODUCTION

The Swiss healthcare system is continuously undergoing change since the implementation of the new Swiss health insurance law in 1996. Most significantly, in 2012 inpatient financing was changed from a system based on cost per case to a system based on a fixed fee per case. Such a significant change has a far-reaching impact on the overall system, especially on the hospital sector. Hospital management, but also national and regional policy makers, are forced to plan and manage in different dimensions than before.

The idea behind a fixed-fee model is that hospital cases can be classified into groups of similar cases, and that these groups can then be treated like products that are comparable, and that are reimbursed with the same fixed amount of money, because it is assumed that they have the same cost structure. The classification rules are based on diagnoses, medical procedures, demographic patient information, and other case-specific data. The combination of all these groups, or products, makes up the medical service portfolio of a hospital. This comparability of medical intervention from a financial point of view is new and opens a variety of new possibilities. In particular, it allows policy makers and hospital management to make decisions based on factual information from the analysis of current service portfolios, as well as the simulation of medical service portfolios into the future. Such flexible analysis possibilities are crucial to make sound infrastructure decisions that will meet patient needs in the next years.

Characterizing and comparing service portfolios in such a way quickly produces large amounts of high-dimensional data. The portfolios need to be visualized, compared, interpreted, and modified by analysts, as well as by groups of managers in live workshop settings. Common spreadsheet programs are too general to cover these tasks well. In order to take full advantage of the possibilities offered by the new reimbursement system, there is a need for tools that allow the various stakeholders to analyze and communicate the data in a flexible and efficient way.

This paper describes a method and a corresponding visualization tool that supports management levels in discussing strategic decisions and future devel-

opments based on current restrictions and conditions.

2 BACKGROUND

Diagnosis-related groups (DRGs) is a patient classification system that links similar types of cases that a hospital treats, to the resources that the hospital uses for the treatment. DRG systems were pioneered in the USA, but are now in use in many other countries (Schreyögg et al., 2006).

The SwissDRG system is a variation of German DRG but refers to Swiss reference values (Swiss DRG, Web). Like in all DRG systems, single cases are classified into a specific class according to their diagnoses (using ICD10), treatment types (e.g. hip surgery), and other case attributes. Each group has a unique code, which enables a precise attribution of a case's revenues to its costs. This results in a shift from a more cost-oriented daily allowance to a product-oriented view, where optimal management along the patient pathway gains in relevance (e.g. in (Gocke et al., 2002) and (Rohner, 2012)). This shift opens the potential for providing a basis for evidence-based decisions in an operative and above all in a strategic perspective.

The dimensions of interest for strategic analysis are: average length of stay, cost weights, and the overall base rate. The average length of stay (ALOS) is used in a DRG system as an output measurement for complexity of the case (Luke, 1979). The other dimension is the cost weight, a relative indicator for the severity of the case, which serves as a measure for resource intensity. Cost weight is recalculated every year based on cost data provided by hospitals to the Case Mix Office (i.e. SwissDRG in Switzerland). Each DRG is assigned specific values for these two indicators, and all the values for all the DRGs are stored in a reference catalog.

The base rate (which is basically determined by negotiation between the hospital and insurance companies) is multiplied with the cost weight attribute to determine the monetary value of a case that is classified into a particular DRG. Besides revenues from private insurance and specialized pharmaceuticals or technologies for special treatments (e.g. specialized oncological treatments) these revenues represent the main income that a hospital can generate from their patients.

As theoretically the cases behind any DRG code should on average represent similar cases in each hospital, these elements make hospitals comparable and allow a benchmark-oriented approach. Comparisons can be achieved by using one hospital's cases, and then comparing them either with the reference values of the DRG catalog, or to the portfolio of a peer hospital, both at the service and at the cost level. Most importantly, this allows comparing the efficiency of hospitals, but it will also enable quality or other assessments.

The services that a hospital offers are influenced by many factors. In most administrative districts (i.e. in our Swiss case corresponding to cantons), service portfolios or service requirements are defined by policy makers. However not all districts decide to provide a full scope of medical services, but might delegate the remaining activities to other providers that can be situated beyond their control or area of direct responsibility. This is complicated by the fact that with the new reimbursement system, patients also gained the freedom to choose their hospital of treatment independently of their canton of residency.

On top of that, there are a number of national policies that impose further restrictions, e.g., the highly specialized medicine act that restricts the number of centers for very complicated treatments, or the changing outpatient health care provision that still heavily depends on resident physicians, who are however overaged and struggle to find replacing practice holders. All these factors push hospitals towards stratifying patient portfolios and focusing on selected medical areas, in order to improve their economic situation actively.

Modern hospitals must engage in strategic discussions about visions, cooperations, specialization, centralization and further infrastructure or organizationally relevant questions. These decisions affect their market position and help them to cope with growing and dynamic competitors both at administrative district or regional levels.

For example, hospitals that today provide maximal service levels, will have to decide whether they will focus on more specific therapies that generate high cost weights (Lüngen and Lauterbach, 2002), or whether they will continue offering a broad range of health care services, focusing on a me-too strategy.

The analysis of pancreas and esophagus carcinoma surgery in Germany as another example has shown that it can be highly beneficial for hospitals to treat a high number of benign cases instead of focusing on the malign cases with high cost weights but bad average length of stay management. This is the case even if the minimal numbers are reached that would be required by the official rules and regulations.

Ultimately, Swiss hospitals will have to adapt their current management models. In order to take the right decisions in this complex environment, hospital managers need to rely on data, and models that are based
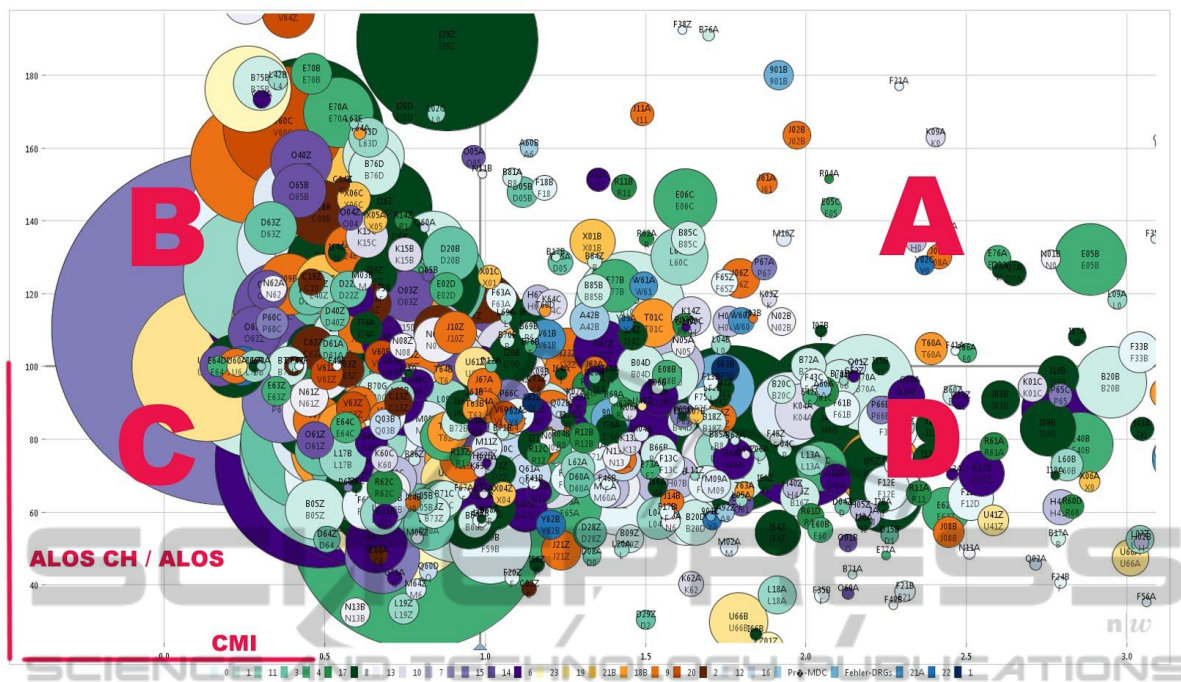
Figure 1: The visual metaphor of the strategic model: a bubbleplot that plots the case mix index (CMI) of a medical service vs. how well the length of stay compares to the country average (ALSO CH / ALOS). This creates four quadrants A, B, C, and D, with different strategic interpretations. The size of the bubble is proportional to the case count for this service. The color shows Major Diagnostic Category MDC.

on that data. Collecting the data is usually not a problem anymore, as modern hospital information systems are well equipped for that job and are commonly in use today. Projecting the data into the strategic models and operationalizing it however, requires new approaches.

3 METHODS

3.1 Strategic Model

As outlined above, the key dimensions of a hospital case are its cost weight - as determined by the DRG into which the case was classified - and the length of stay. Since the analysis of individual cases is too low-level for the kind of strategic questions that need to be supported, the cases are aggregated into groups according to their DRG code. These groups can be considered as the services that a hospital performs.

Working with inpatient service portfolios from various hospitals of various sizes, types, and different geographic areas has shown that plotting the normalized average of the cases' cost weights (also called case mix index CMI) of such a service, versus the deviation of the average of the lengths of stay (also

called ALOS) from the DRG catalog reference (CHA-LOS), produces a graph that is easy to interpret in the context of strategic questions (Figure 1). Each service is plotted as a bubble with the size of the bubble proportional to the number of cases, and the color mapped to any of the other available service attributes (e.g. Major Diagnostic Category MDC, profit, cost, department) depending on the focus of the analysis.

The plot can be separated into four quadrants that each have a distinct strategic meaning, similar to the BCG growth-share matrix used in a strategy or marketing context (Boston Consulting Group, Web). This allows to analyze the strategic positioning of a hospital's inpatient portfolio using the four quadrants (A-D). The quadrants have the following interpretation:

Quadrant A represents the area where the grouped cases generate on average a high cost weight, and result in an average length of stay that is better (i.e. shorter) than the DRG catalog value. We therefore expect the bubbles in this quadrant to be profitable and to represent the services where the hospitals portfolio performs better than the benchmark. Strategically, these activities support the hospital in creating a brand, where the hospital can distinguish itself for quality and performance, and thus should aim at increasing case numbers and building relationships to referring medical doctors. Further options could be to

create a good infrastructure that would attract above-standard surgeons, and centralize the activities of surrounding hospitals in this area. In general, these kind of services should be expanded and require focus.

In **quadrant B** the case mix indices (CMIs) are lower than the average of the hospital, but the average length of stay in the hospital is better than the catalog value. The cases in this part of the grid require detailed analysis of costs. The right infrastructure is of special importance because economic margins are tight. Strategic decisions like outsourcing or PPP (private public partnerships) models should be considered. In general, this area is expected to be at least cost covering and the portfolio overall should be kept constant.

At the bottom left, **quadrant C** represents cases where ALOS ratio is below 100%, i.e. worse than the benchmark and where a low CMI is generated. Because the CMI is low, these activities are potentially loss generating. The hospital has to thoroughly investigate its patient pathways and focus on workflow management, trying to cooperate closely with rehabilitation or care management. Furthermore, direct measures to lower costs need to be taken through implementing for example intermediate care units (IMC) or similar. Additionally, cooperations with resident medical doctors and other hospitals that could take over those cases, need to be investigated. In summary, this area marks activities where the hospital has to reflect, why its activities cannot be executed cost-effectively, or if they could be provided in a day-care or outpatient management setting.

The last **quadrant D** is characterized by high case mix indices and low ALOS ratios. As in quadrant C, an internal focus needs to concentrate on patient pathways and workflow management. From a long term perspective, the number of cases could then be increased. This can be realized through the creation of specialized competence centers, with the aim of attracting cases from surrounding hospitals and referrals from resident physicians. Interesting improvements can also be generated from applying a sound case management that addresses high-outlier issues (i.e. cases that remain in hospital above the high trim point length of stay according to the respective DRG code). Nevertheless this area has a dualistic perspective. Either processes and cost structures are optimized, or the number of cases are reduced in order to improve the overall economical situation.

While the above description is necessarily rough and exemplary, it clearly indicates the added value of such a graphical representation. It serves as a map of reference for discussions without the need to refer to quantitative tables with many dimensions.

3.2 Tool Support

In order to make it possible to apply this strategic model in practice, we developed an interactive visual tool called DRGee (as in "(DR)Gee! Look at this!") that supports the planning process. The tool uses a dynamic bubble chart, similar to (Gapminder, Web), but with a focus on dynamically modifying the underlying data, instead of temporal trend analysis. It provides the following core functionality:

- Load a collection of portfolios (a theme)

- Visualize a portfolio in a standardized way

- Allow selection of parts of a portfolio

- Calculate and display characteristic indicators and summary values of a portfolio or selected parts of it

- Allow the modification of a portfolio by creating a copy and editing individual services to play through what-if scenarios

- Provide the possibility to compare the differences between two or more portfolios

Figure 2 shows the main interface of the tool. The plot that was introduced with the strategic model is featured prominently in the center of the interface. The case-mix index is plotted against the ratio of catalog length-of-stay and actual length-of-stay. The bubbles represent medical services that a hospital performs, and the size of the bubbles is proportional to the number of cases for the service.

Along the left side we find from top to bottom:

- The list of portfolios that is loaded (simple selection of a portfolio in the list displays it and makes it active, portfolios can be cloned here in order to modify them)

- A table of all the services defined in the selected portfolios, showing any number of attributes that characterize each service (services can be sorted, selected, and colored here to make them active and visible, deselected services are shown as ghosts in the background to preserve overall context)

- A display of characteristic indicators and summary values of a portfolio (e.g., total number of cases, revenue, average case-mix index, average length of stay, etc.). There is a choice between the whole portfolio or just the selected subset.

All the necessary controls are contained in these three interface elements. The menus in the menu bar are only used for high-level configuration of the tool (e.g.,
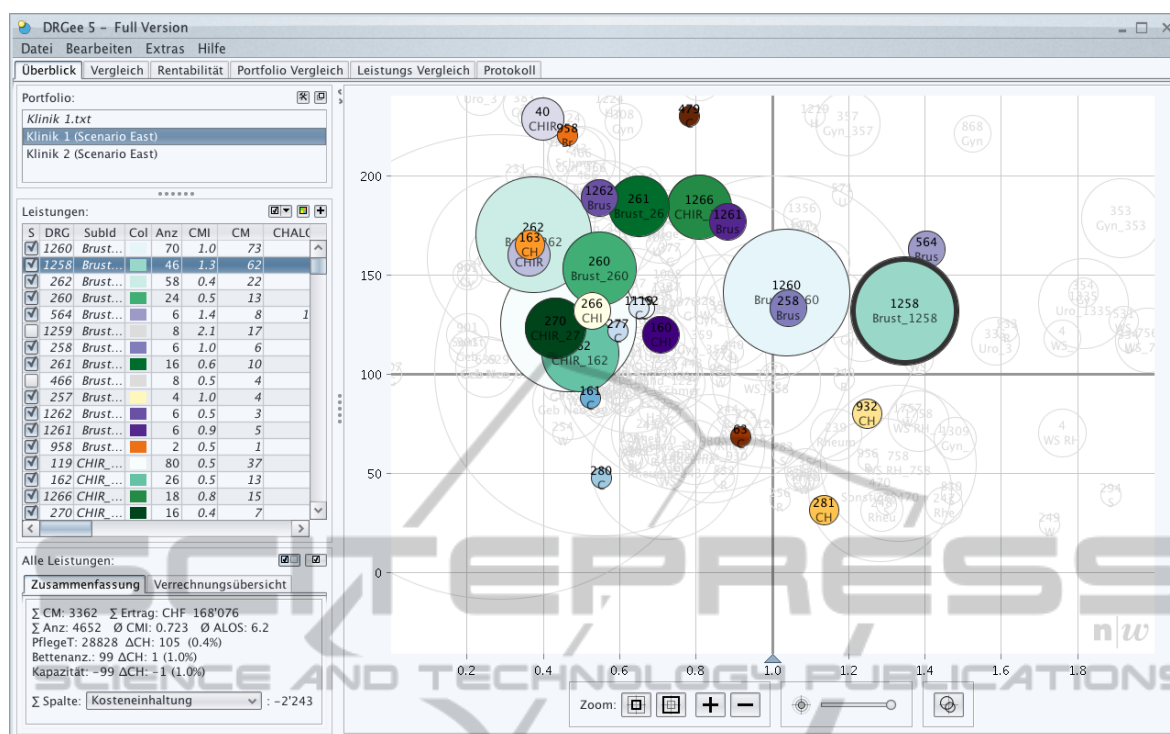
Figure 2: The DRGee tool. The 4-quadrant plot is at the center stage. Services (bubbles) can be directly resized and repositioned with the mouse to simulate what-if scenarios. Controls along the left are for selecting portfolios, services within portfolios, and for displaying summary information. Tabs along the top are plugins that extend the basic functionality, mainly for comparing the various scenarios and documenting the analysis process.

base rate, currency, etc.) and infrequently used functions (e.g., data export, printing, etc.). This was a deliberate design decision in order to ensure the discoverability of the main functionality without having to resort to user manuals.

The software was implemented in Java for platform independence, and uses only a handful of third party libraries, mainly for the look&feel, logging, and PDF generation.

The architecture provides a dynamic extension mechanism, where modules (plugins) can be compiled into self-contained (Java) jar files that are loaded automatically and independently at starttime. Every plugin loaded this way is placed into a separate tab in the main window of the application, as visible along the top of the plot in Figure 2. Encapsulating different features into plugins allows to incrementally increase the functionality of DRGee without having to touch the overall architecture and core functionality of the system. In addition, it supports the easy packaging and delivery of different versions of DRGee with tailored functionality.

3.3 Working with Scenarios

One of the key features of the tool is the possibility to modify existing portfolios in order to play through what-if scenarios, and simulate how the characteristic values of a portfolio change. Each service (bubble) has two dimensions that can be changed: length-of-stay compliance (y-axis) and case count (size of bubble). The case mix indices (x-axis) can not be modified, as they are fixed and predefined by the DRG reference catalog.

To modify a bubble, it can simply be manipulated with the mouse pointer (drag to new position, drag radius to new size). The values in the table are adjusted accordingly. Direct manipulation techniques have the advantage that they are intuitive and efficient if high precision is not required (Shneiderman, 1983).

Comparing the newly created scenario with the original portfolio is challenging. There are three different approaches for visual comparison (Gleicher et al., 2011): juxtaposition (showing objects side-by-side), superposition (showing objects overlaid in the same space), and difference (showing the difference between the objects).
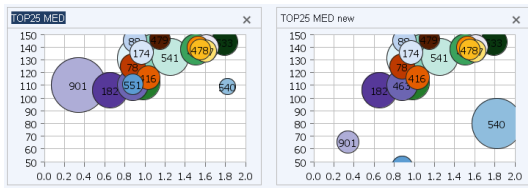
The DRGee tool supports all three approaches,

Figure 3: Comparing portfolios by juxtaposition. Significant differences and overall trends are perceived quickly (e.g., 901 moved and shrank, 540 moved and grew).
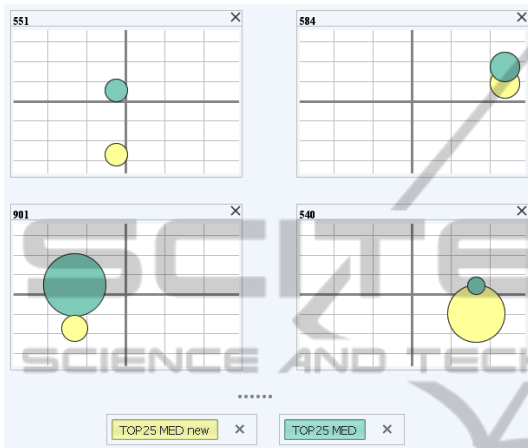

Figure 4: Comparing portfolios by superposition. Individual differences of only the modified objects are shown as small multiples. This provides a complete and precise representation of all the changes, at the disadvantage of losing the overall context.
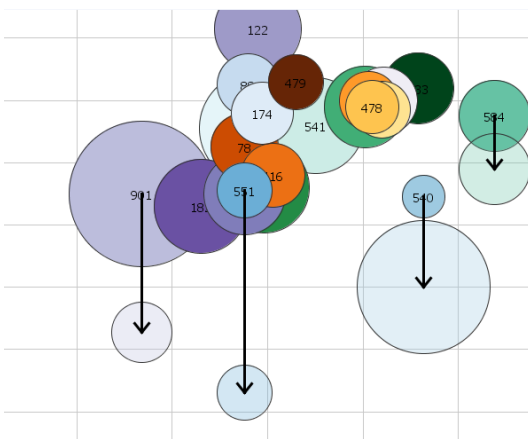

Figure 5: Showing the differences between two portfolios explicitly. Changes in position are marked by arrows. The size of the new bubbles is shown transparently so as to not hide the original configuration in the background.

each implemented as a separate plugin. Figure 3 shows two portfolios juxtaposed. This view works mainly well for detecting a few strong outliers. Superposition was implemented by using a small multiple (Tufte and Graves-Morris, 1983) representation

of the plot per bubble that changed. Each small representation then only shows the changes to that particular bubble superimposed in the same plot (Figure 4). The third approach represents the differences between two plots explicitly as arrows between the original and the new position (Figure 5). This technique allows not only to identify changes in the portfolio but also shows trends (e.g., "DRGs in quadrant C tend to be smaller", "DRGs mostly move to quadrant A", etc.)

3.4 Workshop Use

A special requirement for the tool was that it had to support use in a live workshop setting. As a consequence the following additional aspects had to be taken into consideration:

Animated Transitions

One of the main differences between operating a tool oneself and watching someone else perform the operation is that not all the intentions and actions of the operator are visible, but very often only the results of the actions. Even with close attention, changes can be missed by the audience, a phenomenon known as change blindness (Rensink et al., 1997), leading to mental disconnect and discomfort. In order to address this problem, all the transitions in the tool (zooms, pans, size and position changes of bubbles, change of portfolios, etc.) are smoothly animated or designed as drag and drop interactions, leading the viewers to the next state of the visualization in a continuous way.

Simple Interface

Operating a tool live in front of an audience puts a certain pressure on the operator. It is therefore essential that the user interface is robust and the functionality reduced to a set of minimal yet powerful enough features. All the controls need to be visible so that the audience can perceive the series of actions performed by the operator.

The controls for navigating the bubble plot for instance are not implemented as continuous sliders, but are constrained to just a few discrete buttons (see Figure 2 bottom, below the plot). The first button zooms to a fixed standardized view, and as such serves as the "home" button. The second button zooms to the full range that shows the complete portfolio, which provides the overview. From these two well-defined positions, in-between views can be obtained by using the "+" and "-" buttons that zoom the view by 20% in the respective direction.

Documentation of the Decision Process

The strategic development of a hospital portfolio is an iterative process, and it is often necessary to go a step back and try another path. Traditional tools only provide linear undo/redo stacks, and only the final result is saved. In an analytical process however, especially if it is a collaborative effort shared between participants, the intermediate steps are important as well. Making this path visible and navigable is important to support the analytical reasoning process (Shrinivasan and van Wijk, 2008).
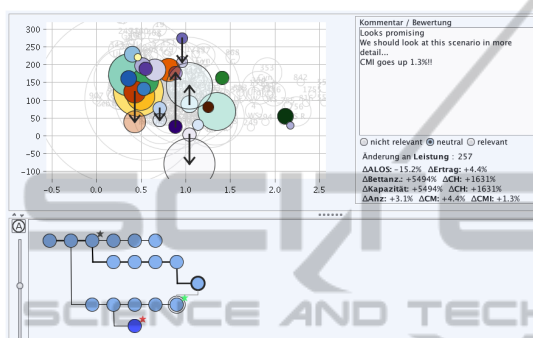

Figure 6: The history of the analysis process is documented as a tree (bottom). Each node represents a different editing step of the portfolio. Nodes marked with a star have a comment attached. Nodes can be rated (green - relevant, red - not relevant). Any two nodes can be compared and their differences visualized (top left) and numerically characterized (top right).

In the DRGee tool, we implemented a history in the form of a tree where every modification to the portfolio results in a new node (Figure 6). Users can navigate to any node in the tree, see the portfolio's state at that point, and branch out from there. A comment can be added to a node to describe the reasons for the modification. Any two nodes in the tree can be compared, and the differences in the two states are shown both visually and numerically as the relative difference of the characteristic values.

The complete history is saved, and the history plugin therefore also serves as a documentation feature. Having access to an automatically generated, navigable and interactive documentation is very useful in the consolidation phase after the workshop is conducted. A viewer-only version of the DRGee tool can be distributed, loaded with the data and the history, to a wider audience for review.

4 RESULTS AND DISCUSSION

The methodology, together with the supporting tool described in the previous section, was used in over forty different hospitals all around Switzerland over the course of four years. The type of hospitals ranged from smaller regional hospitals to hospital groups within a larger geographic region.

Over the course of this time, many workshops with hospital management were performed. Both the method and the tool were refined continuously, but typically the workflow looked like this:

1. Collect the basic data from the hospital and massage it into a set of portfolios relevant for the strategic theme that is of interest. Since the nature and quality of the data varies considerably between hospitals, we used a range of tools for data cleaning and consolidation. Typically these included a primary clean-up in delivery files (i.e. most of the time incomplete rows), load and enrichment of data in a database where consistency checks were performed, and a final validation using known performance indicators for the respective hospital in order to ensure the consistency of the full data load. The final step consisted in creating the DRGee Viewer load files.

2. Analysis of the portfolios by healthcare experts. The tool's analysis capabilities proved very useful to first gain the general overview of the data. Following this, the portfolio comparison functionality allowed to check for outliers, or for yearly comparisons of two specific portfolios (e.g. yearly comparison of the same two clinics). A deeper analysis was then performed by using the superposition comparison. It was possible to directly display single DRG groups for example over time, and compare them in one overview allowing for a direct comparison. The latter oftentimes provided the basis for the simulation within the existing or a new portfolio.

3. Perform a strategy workshop with hospital management in which the tool is used to present the findings of the analysis, explore different scenarios, and discuss future strategies. These workshops typically included senior hospital management, controllers, or infrastructure planners, and are lead by a healthcare consultant that is familiar with the data. Typical questions revolved around what-if scenarios. For example, what happens if I alter the ALOS Ratio of a specific group by adapting my processes considerably? Or what are the effects of increasing the number of cases in a specific DRG or group? Participants found it very useful that they could directly see the effect of changing parameters (i.e. either the ALOS ratio or the number of DRGs per group) and validate and further discuss the results either in the various

portfolio comparison views, or see the profitability effects in the summary values.

4. Provide the data used in the workshop and any resulting modifications to the portfolios to hospital management, together with a limited-functionality version of the tool for further discussion and communication. The recipients were able to profit by continuing the work beyond the guided workshops. The wider distribution of the tool, also to non-expert users, did not turn out to be a problem. The tool proved to be intuitive enough so that the required support was not significant.

In the workshops, the tool is used in front of a group of people. This prompts the question, if there is an opportunity to extend the tool to provide more explicit support for collaboration. There are various scenarios in which collaborative visualization can occur. In the space-time matrix that is used by (Isenberg et al., 2011) to categorize the design space, our implementation of DRGee currently corresponds to a co-located synchronous scenario, where a group of experts in the same room interact socially to create a common understanding of the data. Large interactive walls or multi-touch tabletop displays are technologies that are of interest in this context. However these devices are not yet widely available at the places where hospital decision makers work, which is why the practical potential of such approaches is still limited.

A web-based version of DRGee would facilitate a distributed asynchronous scenario, with access to the tool and the analysis results from arbitrary locations at any time. The focus would not be on social aspects of a large (mostly lay) audience such as investigated by systems like Many Eyes (Viegas et al., 2007), but more on the asynchronous aspect of supporting collaborative analysis across time.

Examples of the strategic insights and decisions that resulted from this work are:

- A group of hospitals reorganized their main operative theaters, because services were delivered far more efficiently in one hospital than the other. Consecutively the costs were reduced substantially, leading to an overall benefit within this sector of activity.

- The tool helped a smaller regional hospital to recognize its strategic fallacies, and thus proceed to a strategic partnership by giving up a certain part of their activities and re-focusing the hospitals overall market approach.

5 CONCLUSION

We have developed a tool to visualize and edit hospital service portfolios in live workshop settings. The tool is embedded in a strategy methodology that is used by hospital management and healthcare consultants. The method is actively used and has been successfully applied in more than forty hospitals around the country so far.

Strategic planning is difficult since the set of variables to consider is multidimensional and complex. Having a tool at hand that supports modelling, visualization, evaluation, and comparison of various approaches while self-documenting the individual steps, proved to be extremely helpful and often acted as a catalyzer in the planning workshops.

The supporting tool goes beyond graphics towards an interactive toolset that allows to understand complex situations intuitively and discuss strategic challenges. In this way the DRGee Viewer distinguishes itself from purely operative tools that are available in the market, as it is embedded in a logical framework. This makes it robust enough (by using the same portfolio structures at all levels) to provide a stable, comparable and evidence-based foundation for decisions.

The approach has the potential to be used at a more complex level, beyond a single hospital groups perspective, towards a more public health oriented dimension. This is where the value of such a tool could be useful for health service planning and provision.

Other directions in which the system will be extended are twofold:

- On the technical side, a migration to a web-based system is planned, to allow concurrent and collaborative work.

- It is planned to incorporate more data sources, such as quality data, demographic data and geographic conditions, and a comprehensive simulation within this new data landscape will be developed.

In summary, the method supported by the DRGee Viewer reflects claims in literature (Geissler et al., 2011) that DRGs are not solely a tool for financing hospital services, but are also well suited for increasing transparency, inducing efficiency and supporting the hospital management in strategic decisions.

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