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TOWARDS COMPLIANCE IN ORGANIZATIONAL ENGINEERING - A CASE STUDY

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Abstract

Information Systems for decision support are used in healthcare for many years. While administrative, accounting-related systems have been accepted with more or less success by decision-makers, this study is devoted to methods of conceptual modeling in clinical information management – especially against the background of assuring a high quality level in an increasingly networked healthcare sector. There are large differences in the use of models of Clinical Practice Guidelines (CPG) and their implementation in process descriptions as Clinical Pathways (CP). The paper examines the usefulness of diagrammatic representations and models as well as methodological support in general as well as the willingness of individuals to deal with these. Based on an exploratory case study, the concept of a model-driven method from the perspective of domain experts is evaluated and the impacts for modeling approaches are derived.

Keywords: Compliance, Business Alignment, Conceptual Modeling, Hospital Information Systems.

1 Introduction

Research in the field of organizational engineering from an IS perspective has recently been focused on the use of IT in dynamically changing business settings. This has been done particularly with regards to a strategic perspective (Akkermans and van Helden, 2002; Petter *et al.*, 2008; McLaren *et al.*, 2011). Literature lacks empirical findings that could provide starting-points for an operational improvement of process compliance in business organizations.

Of interest are techniques that could help to specify and manage processes aligned with business obligations; like approaches for the sharing of know-how (best practices), data-driven process control and broader topics such as process simulation and performance management (Governatori and Sadiq, 2009). The necessity to keep processes compliant is especially valid in enterprises whose processes operate "at the limit". Hence, no tolerances exist – due to governmental regulations, domain-specific constraints (e.g. quality) or due to short of financial (economic) safety margins.

This study considers the topic of model-based management in hospitals. In this domain there is a need for continuous compliance with current medical evidence and hospital-specific best practices on the one hand and organizational constraints like economic objectives on the other hand. This leads to a constant pressure on the medical staff in operative processes (Fichman *et al.*, 2011).

Design oriented research has shown that semiformal models can be used – under certain conditions – for further processing beyond their original purpose of the documentation of business requirements, see e.g. (Bögel *et al.*, 2011; Dietz *et al.*, 2011; Becker *et al.*, 2007). A certain set of assumptions is associated with the developed artifacts. Exemplarily could be named:

A1 The diagrammatic representation in conceptual models facilitates the clarity of represented data allowing a rapid integration of human actors in a communication process and facilitating consensus about represented facts

A2 Models allow a methodical, systematic handling of problems within an artificial model world. Algorithms and/or tool support can operate on the formal elements of conceptual models and thus automate all automatable activities (e.g. test on completeness, consistency, evaluation of ratios, identification of semantically equal model parts, etc.).

A3 Models can serve as a knowledge base (which effectively means the ability to reuse models). The central data storage in an electronic modeling environment could for instance be the basis for a comprehensive analysis of models across domains, but on the condition that integration conflicts are solved. It also offers the possibility of a later context-based search ability of analysis results. Both contribute to the ability to handle the complexity in the field of organizational development.

Investigating the relationships between organizational factors and model use gives us a deeper understanding about the critical success factors for the practicability of model-based management for process compliance.

This study is based on the case of clinical processes in a regional healthcare network. The essential benefit of Clinical Practice Guidelines (CPGs) and Clinical Pathways (CPs) for quality assurance and cost savings in the clinical exchange of information is widely accepted and empirically proved (Panella *et al.*, 2003, 2008; Rotter *et al.*, 2008). However, there are still big differences between their general use and their implementation in process descriptions (Woolf *et al.*, 1999).

This study explores the following research questions:

RQ1 What is the current situation within hospitals and healthcare networks and the status of the support?

RQ2 What are the key factors determining an enhancement of CP development and control?

As the main contribution, this study explores the requirements for the usage of semiformal models in healthcare. As a result, an approach is proposed that allows a purely model-based compliance checking between CPGs and CPs as one main use case (Schlieter *et al.*, 2011). An example is shown,

which demonstrates an ongoing management of clinical processes on the basis of models. That means that CPs are not implemented one-time but rather interpreted as a constant information resource that is changed according to professional requirements and organizational constraints.

The paper is structured as follows: First, we give a short theoretical introduction into the foundations of clinical process management. Afterwards, a survey concerning the use of CPGs during the construction phase of CPs and the evaluation of process descriptions that are modeled in the case scenario is presented. Subsequently, the impacts of the results for model-based approaches are discussed and an approach of resolution is delineated. The paper closes with a discussion and directions for further research.

2 Clinical Process Management

CPG and CP have evolved into important tools of clinical process management. Developed with different purposes, both concepts standardize treatment processes. CPGs are built with the focus on aggregation of current evident clinical knowledge, which could e.g. gained by randomized clinical trials. Thus they foster primarily the quality of treatments, secondarily cost aspects. CPs, on the other hand, are built individually by hospitals with the main focus on process efficiency and are driven by cost savings. The further comparisons of these concepts will underline their synergies, which can be achieved by IS-supported integration of the recommendations of CPGs and the hospital processes of CPs. Thus, the content of CPGs should be able to be directly integrated into CPs, and, from the viewpoint of the CPGs, CPs provide a way to actively distribute evident knowledge. Therefore, in the following sections, we study the terminological foundations, the responsibilities for development and maintenance, as well as the type of implementation.

2.1 Clinical Practice Guidelines

The term guideline is very frequently used in clinical domains for an assortment of different concepts. In fact, physicians use it for CPGs, Standard Operation Procedures, Internal Rules, Internal Guidelines or Statutory Provisions. Internal guidelines or medical standards formulate exclusive medical facts of symptom combinations or care situations, which are adapted within a hospital (Woolf *et al.*, 1999). Standard operation procedures (SOP) are narrow action suggestions for dedicated care sections. They describe repeatedly performed operational procedures that have to be abided in an organization.

To avoid misunderstandings, we use the term Clinical Practice Guideline. They are defined as "systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (Field and Lohr, 1992). They contribute to clinical care by the inclusion of specific recommendations and sufficiently supporting evidence with a clear structure (Wollersheim *et al.*, 2005). Typically CPGs are developed regionally or nationally (Thomas, 1999).

Usually medical societies and their specialists develop and maintain CPGs; however, sometime health insurances, manufacturer of pharmaceuticals or other associations implement them, too. E.g. in Germany, a guideline manual helps to design "good" CPGs. It also recommends the utilization of a standard nomenclature of the Society of Medical Decision Making for modelling clinical algorithm within CPGs (Barak *et al.*, 1992). However the development team is free to choose entirely prosaic descriptions or any combination of text, tables and conceptual models.

2.2 Clinical Pathways

Clinical Pathways (CPs) are specific, standardized descriptions of clinical processes for defined combinations of symptoms that are adapted to clinical conditions (De Bleser *et al.*, 2006). They are geared to the whole multidisciplinary care process of patient type. As Panella and Vanhaecht (2010) stated, CP are more than only the structure of a care process and a part of the electronic patient records. They are "a patient-focused concept, a tool to model the care, a quality and efficiency improvement process and a product in the patient record" (Panella and Vanhaecht, 2010).

Based on a meta-review, Kinsman et al. (2010) derive five constitutive characteristics for CPs from the three sentinel articles (Campbell *et al.*, 1998; De Bleser *et al.*, 2006; Vanhaecht *et al.*, 2006). First of all it has to be a multidisciplinary plan of care. Furthermore, CPs should be used to foster the adaptation of CPG or other sources of evidence into local structure. Thirdly, the treatment processes of CPs have to be described in their essential steps. Fourthly, timeframes or criteria, which lead to alternative treatment procedures depending on the patient characteristics, are implemented, and, at last, CPs are characterized by the aim to standardize care for a specific indication in a population.

Especially the second point highlights the role of CPs to channel the evidence of CPGs, due to the inclusion of administrative, nursing, and other management processes (Weiland, 1997). They are a fundamental tool of clinical organization for quality and cost-related process management (Moy, 1997; Panella *et al.*, 2003).

How a hospital achieves the aims related to CPs, depends strongly on the quality of how CPs are implemented. CPs have to be designed accurately and comprehensively, so that they are understandable for doctors and thus applicable. No obsolete treatment processes should be documented, to be able to treat patients according to the actual evident knowledge. Furthermore, CPs can only be applied, if they are available for all involved persons.

Diagrammatic forms are standard to conceptualize and to manage CPs. Typically, CPs are modelled in the flowchart notation, Business Process Modelling Notation (BPMN) (OMG, 2011), as Activity Charts of the Unified Modelling Language (UML) (OMG, 2010), or are proprietarily developed in-house.

2.3 From Clinical Practice Guidelines to Clinical Pathways

As stated in the previous section, the consideration of evident knowledge captured in CPGs is an essential task of assuring high quality healthcare. Nowadays, for most hospitals, building and *managing* evident CPs is a very resource-intensive task, which is typically performed manually by physicians. Considering the life-cycle of CPs from creation over utilization to a continuous improvement, different potential facts can be indentified for the relationship between CPGs and CPs. The phase of creation is a first starting point. Beside the manual development, some approaches are published proposing a reference model based approach (Thomas, 2006) for a CPG-driven development (Jacobs *et al.*, 2007; Schlieter and Esswein, 2010). Those approaches lead to a concrete CP. However, they assume that the CPGs could be easily transformed into reference models. However, up-to-now CPGs are not built with the tools that reference models offer. Furthermore, these approaches are limited, if the CPG become obsolete and have to be altered because they have no inherent mechanism to visualize the changes. In addition, they are not applicable, if a CP is already built and a hospital wants to check how well it complies with the corresponding CPG.

Bögel *et al.* (2011) deal with these two problems by designing a method for the integration of CPGs and CPs within the phases of utilization and improvement. The main objective of their approach is to "reengineer" the relations systematically with help of domain experts to build an integration model that stores the relations between these models. With the help of this knowledge of relationship, it would be possible to present CPG recommendations for CPs, or to understand, which elements would take effect by CPG changes. However this approach is extensive, presumes domain knowledge of specialists and does not support the pathway development.

Beside the human-centered CP implementation, there is a plurality of approaches, which focus on a high formulization of CPG-rules to transfer the non-formal rule-system of the CPG to the decision support systems (DSS) of the HIS. Such methods are for example ProForma, GLIF, GUIDE, or Prodigy (Peleg et al., 2003). The DSS supplements the CPs within a hospital. Therefore the HIS has to be able to interpret the formal language and to combine it with the specific state of the patient documented in electronic health records (EHR). The approach of that transformation of CPG into coded information (CI) structures is thus rather an extension of the paths than a methodology of a systematic transfer and organizational implementation.

In conclusion, there are no holistic approaches that guarantee compliance over the layers of CPG, CP and computer-interpretable workflows (Juhrisch *et al.*, 2011), without high intervention into the

domain or the assumption of an unrealistic negotiation between the actors of these layers. This means that models in different domains therefore should use a common terminology, and the semantics of the terminology must be clear to all sides (all roles that are participating in the modelling process). This involves of course a practicability of the commonly used language for each individual domain. In Section 4.2.5 we will discuss some way to avoid the here mentioned conflicts and highlight an approach that especially addresses the domain conflict.

3 Research Method

Case research is part of different qualitative research methods in IS research (e.g. beside field studies or grounded theory). We decide to conduct the case research strategy because, up to now, there are no in-deep investigations of this topic (Benbasat *et al.*, 1987). So the case study would help to examine the phenomena of process compliance in the health care area in its natural setting (Yin, 2003). Furthermore, according to (Christenson, 1976) this research method is adequate to capture the domain knowledge of practitioners. Our case research is based on a positivistic epistemological assumption. We selected an exploratory case study approach relying on qualitative data collected by using both semi-structured interviews, questionnaires and document reviews, two important forms of evidence collection that satisfy the principles of data collection of (Yin, 2003): (1) multiple sources of evidence, (2) a case study database, and (3) a chain of evidence. For our research the studied hospital network within Germany (see below) provides a real world example, which provides the chance to analyze empirically the relevance and the potentials of model based approaches to domain level compliance. The aim of the exploratory design is to examine whether it motivates further research on the perceived problem or it demonstrates that the problem is not relevant for actor and doesn't even exist.

Our investigation was conducted in 14 hospitals, each in a different area of a regional stroke network (SN), in East Germany. We studied a CP development project lead by the stroke unit of the network (SU). Thus a single case study with multiple embedded units of analysis, which are the hospitals of the SN, was conducted. The inquiry has been accomplished mainly through a questionnaire that had been sent to all members of the network. In addition, the supervisor of the network was interviewed in order to get a general overview of the activities in the network. Furthermore, two audits were conducted to verify the results. In these audits the existing CPs where checked with regards to the compliance with the requirements of medical guidelines and the content and also concerning the use of the model suggestions. Depending on the number of attending physicians, either one or two physicians of the medical management level of the 14 partner hospitals from the SN were interrogated through the questionnaire. Altogether 23 questionnaires were sent, whereof 14 ones were sent back and whereof 12 ones were evaluable. This corresponds to a return rate of 60%. The questionnaire is divided into two parts. In the first part special information to the collaborative work are made. The usage of CPs and CPGs are the focus in the second part.

4 Case: Stroke Network in East Germany

4.1 Case Study Design and Case Description

In industrialized countries stroke (apoplexy) is the third major frequent cause of death and the most frequent reason of lasting physical handicaps (Kolominsky-R. *et al.*, 2006). In the acute stroke care the capabilities of therapy worsen with each minute, in which the stroke is not diagnosed and not treated accordingly. An immediate medical intervention and therefore especially a radiological diagnosis by an expert are necessary to avoid consequential damage. One of the main concepts for an adequate intervention is the stroke unit (SU), in which interdisciplinary teams are available 24/7 to assure a fast and direct treatment of stroke patients.

However, in territorial states it is nearly impossible and especially hard to be financed to guarantee an identical care infrastructure in regions with less population as the stroke units do in the huge cities. Nevertheless, each patient should be treated independently from the place of incidence according to the evident medical knowledge. The stroke network (SN) was founded to assure a fast decision-making, to improve stroke care, and to provide expert diagnosis in the region. Within two years the SN was growing into an important stroke care network in the region. At present, fourteen hospitals are

part of the network, which means that almost all regular hospitals of the regions are a member of the network. The know-how of the SU is available for the whole region through the tele-medical applications that preclude also cost-intensive and redundant structures. This way the level of care has been improved significantly in structurally weak regions.

With help of a video conferencing system a stroke expert of SN can assist the diagnosis procedure in smaller hospitals, which are the direct point of care for stroke patient. Furthermore, radiological images are uploaded on a network-wide picture archiving and communication system (PACS) and can also be used to support the diagnosis. Thus, it can be quickly decided, if the patient has to be transferred to other hospital by helicopter or which therapy has to be done.

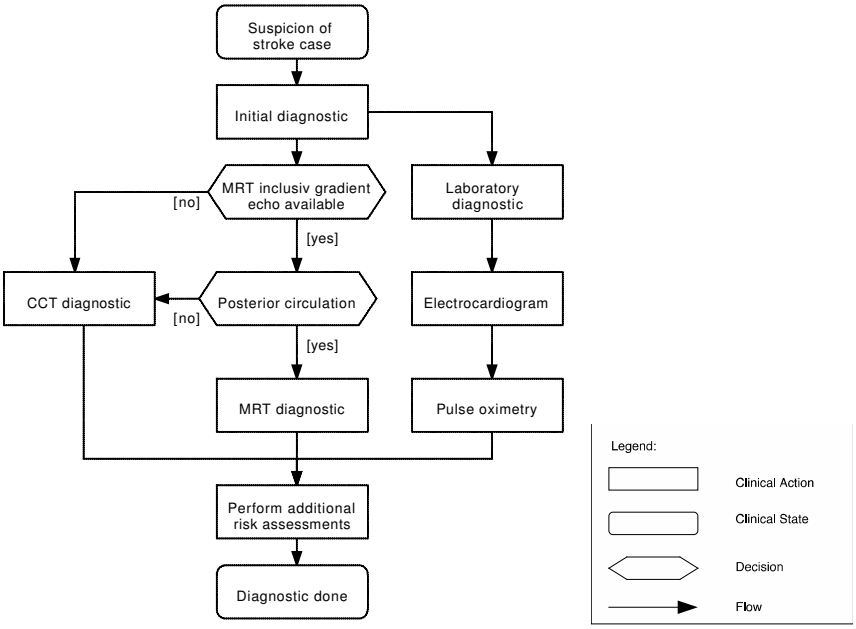

Figure 1: Modelled Clinical Algorithm of stroke CPG

The different suspensions of employees and the differences of the technical infrastructure necessitate defined responsibilities and processes within the network. Therefore, the SU defines and controls quality standards and CPGs (such as Figure 1), which define how stroke patient have to be treated, when an external physician has to be called, and what time-frames the elementary diagnosis steps have. The CPGs are used to transfer best practice of the SU to the partners, who implement them as CPs (see Figure 2). They serve the definition of works principles of the network. Conceptual models are basically used within the CPGs to describe the treatment algorithm. Tables and plain texts complement them.

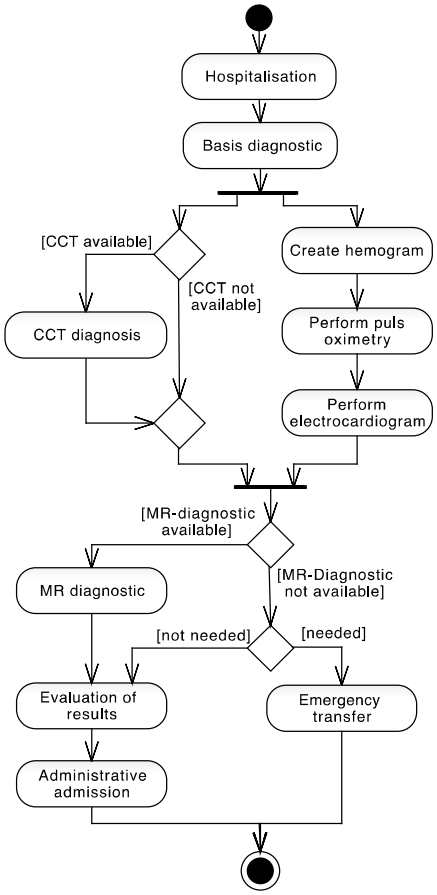

Figure 2: Part of the Clinical Pathway for the diagnosis of stroke as an UML activity chart

4.2 Data Analysis and Results

The above mentioned survey was used to analyse the current situation within the SN and the status of the support. Furthermore the partners were queried about their preferences for an enhancement and redesign of the process descriptions. Additionally to these research questions this paper derives some conclusions for a possible enhancement in a model-driven way before presenting a corresponding integration framework in the next section.

According to the survey, in average 93% of all apoplexy cases are covered by a CP of the hospital. This high value comes from the high potential for creating standards in treating apoplexy.

4.2.1 Support within the Network

The SU supports its partners with respect to the embedding into the network and the creation and execution of CPs. Corresponding to the survey the support in the form of documentation standards and the specification of content was classified as useful. The SU so far created quality forms and checklists as documentation standard. The content specification consists of those CPGs the SU is already using on their own. Also the support for the project organization has been rated positively.

54% of all respondents see a high potential for enhancing the methodological description, how to adapt the process descriptions of the SU to the local situation. This is connected to the question of how documents are used, which has been rated negatively be the respondents, too. Explicitly named deficits were: The documents were too confusing or unclear so that they were not used and a personal contact was necessary; no systematic introduction into how to use and create CPs, and no support by tools for this. This is underlined by the fact that over half of the respondents (53%) did not follow any clearly defined project organization for the introduction of CPs.

Even 81% of all respondents answered that they would like to enhance the available process library. This library could contain process templates for creating own CPs. Several other details like explanations on how to use the documents or an enhancement of diagrammatic descriptions and the availability of templates were rated neutrally or as not so important, and these answers partly had a high variance. The high variance could be due to the varying level of the hospitals and their employees. An evaluation of the existing documents showed that 92% of all respondents rated quality of the medical content of the documents as very good, but 50% of all respondents said that the usefulness of the documents for administrative concerns is not very high. Figure 3 summarizes some of the problems that were ranked by the respondents.

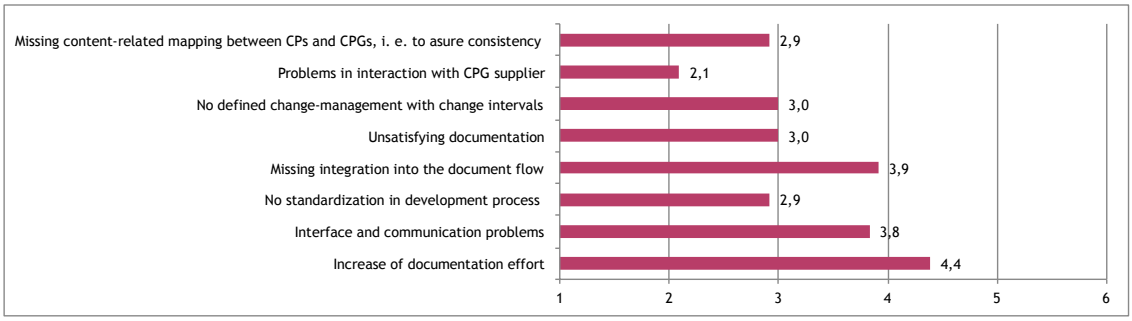

Figure 3: Answers for "Which problems did occur when implementing / executing CPs?"

4.2.2 General Questions about the Use of Clinical Pathways

The main goal of CPs, nearly throughout the respondents answered with "fully agree", is the quality assurance of the medical treatment. Also the economic goals like a decrease of the bed-time and lower operational costs have been nearly constantly answered with "agree" or "fully agree". This reflects the use of CPs as a comprehensive management tool for enhancing medical processes, saving resources, and creating transparency.

On the question of what triggers changes of the CPs the most answers were changes of the current therapy possibilities, changes of the specifications of the SU, and changes of laws or other regulations. 58% of all respondents do routine check of their CPs, in average all 20 months. However, routine checks are not the main cause for changes, and also changes of organizational circumstances are not that often resulting in changes of the CPs. When auditing the content of the CPs in 5 of the hospitals, interestingly in 2 of these the current version of the CPs did not reflect the current situation. One reason could be the lack of standardization when announcing changes (where email is most often used so far). Readability and easy comprehensibility are highly important for the correct use of CPs in practice. Within the network different forms of representing CPs are used. The respondents were asked for their preference and problems with the actual use of certain ways of representation. By far the most preferred way of representation is a mix of text and diagrams. This is surprising, since the audits of the content showed in most cases purely textual or descriptions in tabular form.

4.2.3 Consequences for the Integration Framework

Both parts of the survey demonstrate the usefulness of standardized guidelines — in the form of CPGs — for the creation of hospital-specific CPs. A high usefulness was demonstrated with respect to the medical content of the CPGs to ensure a high quality of medical treatments. Both the support of the SU as well as the provided documents were rated as highly useful for providing content, not only medical, but also partly organization (as e.g. responsibilities). However, when it comes to form instead of content, e.g. guidelines for the structural design of the CPs or the integration of CPs into the general document flow, both the SU's as well the CPGs' support in general still fall behind. When it comes to problems with the support, communication problems as well as too high efforts when implementing and executing CPs are ranked as highest, while problems with the SU per se are ranked as lowest. The respondents answered that all the content areas — medical treatment, temporal specifications, responsibilities, and administrative concerns— are well covered in CPGs.

One question was about the respondents' expectations on CPs. Interestingly all answers in a long list were rated as high (see Figure 4), starting from the quality assurance by an optimization of clinical processes and finishing with decreasing the number of re-hospitalizations, which was still averagely ranked as 4.5 on a scale from 1 ("don't agree") to 6 ("fully agree"). So the expectations on CPs are very high, which means that CPs nowadays have high importance in clinical management.

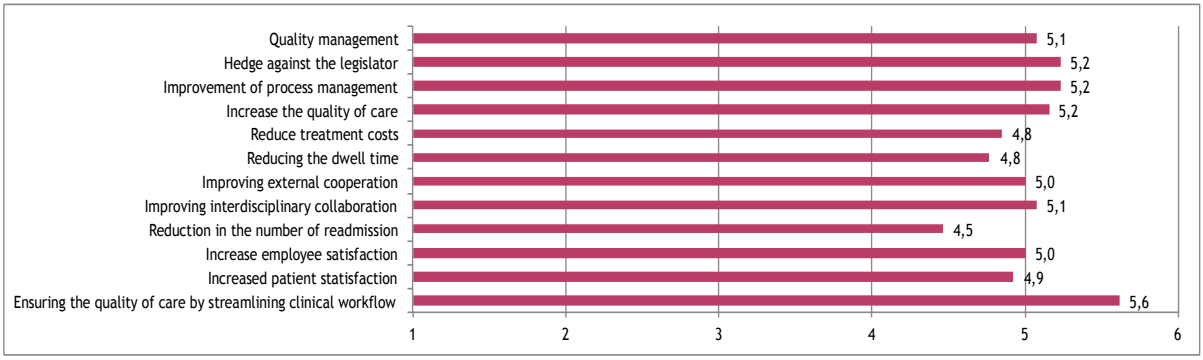

Figure 4: Answers for "What are your goals concerning the use of CPs?"

All this shows that the general idea of CPGs is already working well and really helps the hospitals for ensuring a high quality. However, the implementation and execution of CPs on the basis of CPGs still needs high efforts, is mostly done manually due to the high complexity, and lacks clear guidelines for how exactly to derive CPs from CPGs as well as clear guidelines for the form of CPs. A higher formalization of CPGs are necessary, but even more clear guidelines on how to use CPGs to derive CPs are necessary. A representation by a mixed form of text and diagrams is both by far highest ranked as expected to be useful as well as actually used. Interestingly purely diagrammatic forms are used quite often, but their usefulness is only ranked as average. On the other hand, a tabular representation is ranked as useful, but this form is used least (see Figures 5 and 6).

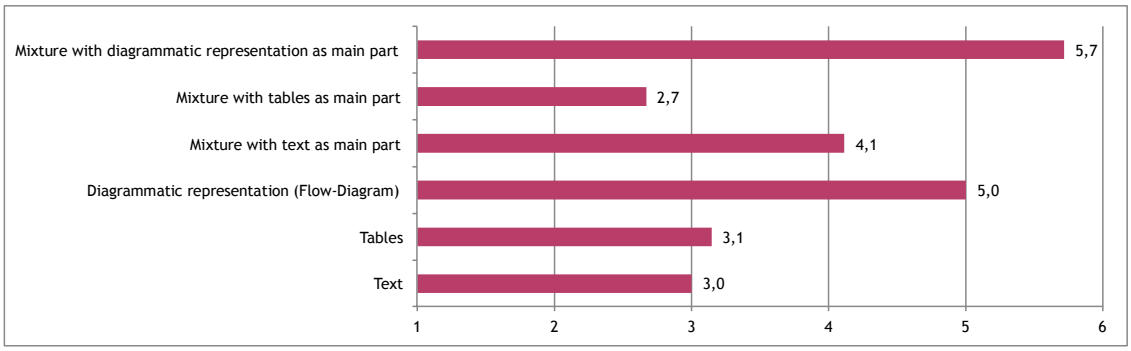

Figure 5: Answers for "Which ways of description are you using for CPs?"

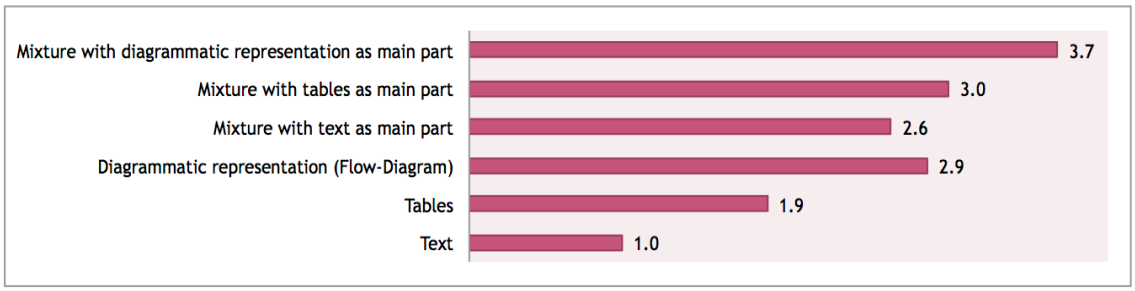

Figure 6: Answers for "How do you estimate the comprehensibility of CPs with respect to different ways of representation?" (Shown are average inverse ranks)

4.2.4 Impacts and Implications

The above shows that a formalization of CPGs will be useful and supports the model-driven approach of this paper. However, too much formalization is counterproductive. A semi-formal approach is therefore the best compromise to achieve a good formalization without restricting the textual freedom too much, to still be able to describe complex medical facts. The mentioned communication problems support the concept of the domain conflict as described above. This supports the usefulness of the Description Kit Approach – see next section – for the case of hospital management. The Description Kit Approach (DKA) can attack the lack of clear guidelines for implementing CPs. The algorithms of the DKA furthermore can even partly automate the transformation process between CPGs and CPs. The following section will discuss how to do this.

Before doing so, the importance for an improvement of CPGs and CPs should be exemplarily highlighted by the fact that implementation or execution problems of CPs (see also again Figure 3) not only hinder the applicability of CPs, but even visually prevent their use: Figure 7 shows a correlation between the level of problems when implementing or executing CPs in a hospital, and the degree, how well these CPs cover the treatment workflows in question. A regression shows significance ($p= 0.044$) with $R^2= 0.32$.

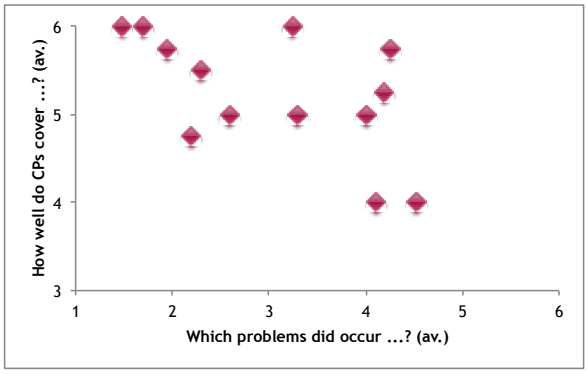

Figure 7: Answers for "Which problems did occur when implementing / executing CPs" vs. "How well do CPs cover your stroke treatment workflows?

4.2.5 The Description Kit Approach

The Description Kit Approach (DKA) is a semi-formal modelling approach that was introduced especially for the case of cross-organizational and cross-domain modelling scenarios, in which models should be used to directly address some domain-specific problems (Dietz and Juhrisch, 2011). These models should yield support for an at least semi-automated problem solution without destroying the adaptability to new problem fields and an on-going development and change of language.

The DKA introduces a guideline-oriented ways not only for the use of the created models, but also for the creation of these models. These guidelines serve as a kind of "glue" between both the formal parts of the model language as well as the fixation of language patterns – therefore the restricting parts of the language – and the freedom to express facts in natural language – therefore the adaptable and "soft" parts of the language. This allows a high expressional freedom for creating domain-specific models that still can be transferred to and understood in other domains. The usual approach of domain-specific languages to highly constrain the language to avoid integration conflicts is replaced by guiding the model creator through the model creating, so that the expressional freedom does not destroy the comparability of so created models across different domains.

The DKA also offers some algorithms to compare models from different domains in a semi-automated way, as well as for the creation of ratios for the applicability of specific model parts with respect to isolating these parts as loosely coupled and coherent "services" as well as orchestration capabilities (Dietz *et al.*, 2011). These algorithms can be adapted to a certain problem in mind, e.g. a compliance check between different domains. In the presented case these algorithms can therefore be used to check the compliance of CPs with respect to their corresponding CPGs. The guideline-oriented aspect of the DKA also supports a clearly structured process for creating CPGs in a way that their

comprehensibility as well as their comparability with the CPs in question is ensured – which especially means a clear understanding by different experts and a decrease of documentation and communication efforts.

5 Conclusion

CPGs and CPs show great potential in hospital management. However, the lack of standardization of describing CPGs as well as CPs, but even more the lack of standardization of how to create CPs based on their corresponding CPGs still creates some problems. CPGs should be able to create hospital-spanning standards for diagnostics and treatments, which different hospitals can use to derive concrete workflows in the form of CPs. This leads to the question, how to check if a CP complies with the corresponding CPG.

The presented case study supports these considerations. It shows the high usefulness of CPGs and CPs as well as the high expectations on these, but also illustrates several problems that can be summarized by a lack of methodical support of CPGs per se. The CPGs used so far primarily contain content, but are not sufficiently guiding the hospitals through the creation of CPs without institutional and personal support of the SU. The CPGs as a way of standardization for medical processes are highly acknowledge, while on the other hand they still may create a burden with respect to high manual efforts and communication problems.

A pure formalization of CPGs could not help in this situation, especially since the medical domain needs a certain freedom in expressing medical facts. Therefore semi-formal modelling methods could offer a solution, since they still offer enough freedom by textual description. However, to use such methods effectively, a common understanding and a methodological support for the creation of CPs is necessary; especially integration conflicts have to be solved.

A possible solution in the form of the Description Kit Approach is outlined. The case study supports the usefulness of several ideas that originally lead to the formulation of the DKA. The presented case study should continue in future research to directly assess the usefulness of the DKA in comparison to other modelling approaches (and other description techniques).

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