Validation of an implementation methodology for information systems in healthcare

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Summary
Integration and implementation of information systems (IS) in healthcare is a challenging task. Only a minority of US (as well as European) hospitals have, for example, fully implemented computerised physician order entry (CPOE) in their daily practice (see HIMSS analytics homepage). The reasons for this situation are many: late computer implementation in healthcare compared with other industries, resistance by professionals, complex and sometimes unpredictable workflows difficult to model in an IT system, past failures and mistakes in implementation, to mention just a few.

Since the implementation of ICT in healthcare is known to be problematic, a universally applicable framework would be of use. Although many case studies are published, only a few publications focus on practicable lists or methodologies supporting the implementation of IS. On the basis of a literature review, the only generally applicable framework is chosen for validation. The framework consists of 110 success and 27 failure factors for different types of healthcare IS. Validation is performed by a retrospective analysis of CPOE implementation in the hospital of Thun (Switzerland).

Overall, from our perspective, the framework offers a valid possibility for planning and implementing CPOE in a hospital, although, on a one-off basis, the framework could be widened. In general, it offers a detailed and usable list of success and failure factors for implementation of IS in a healthcare institution. Although distinct differences between e.g. CPOE and other IS exist, many of the items indicated in the framework can be used in a general setting.

The framework under study could thus enable many hospitals or other healthcare institutions to successfully implement information systems, even though the list of items to be observed can never be complete.

Introduction
In healthcare in general and especially in hospitals, working routines, workflows and interdisciplinary work are nearly always complex, non-linear, in many ways unpredictable and sometimes even chaotic [1]. Due to the publicly financed structure of many hospitals, financial support for the introduction of computerised systems is often lacking and for years knowledge of the potential advantages of computerised support was limited. Last but not least, the working environment is quite well organised even though most hospitals still rely on paper-based systems. Paper as an information source has distinct advantages over computerised systems and for decades has proven its suitability [2]. These are only some of the reasons why for many years information and communication technology (ICT) was not widely used in hospitals.

The latest booster effect in support of the introduction of information systems (IS) arose from the report “To Err is Human” by the Institute of Medicine (IOM) [3] and thereafter from initiatives of many quality organisations, e.g. the Joint Commission on Accreditation of Healthcare Organisations (JCAHO) and the Leapfrog Group. Many publications have so far reported on enhanced patient safety, decreased adverse drug events, relevant return on investments and improvements in work processes and workflows [5, 6]. But implementation of IS harbours new problems as well. Systems may be badly designed, may be incorrectly used [3] or lead to wrong conclusions. Several reports also show increased error rates in prescribing medication [7, 8], despite sophisticated algorithms. Furthermore, some studies show totally new behavioural problems such as goal conflicts when some actions are monitored: nurses pay more attention to monitored activities and neglect activities that would have been prioritised in the traditional setting [9]. In summary, there may be a price to pay for increased patient safety: the risk of safety.

Thus, we nowadays face an enormous gap between knowledge of problems created by the current system, the available technical resources and the realisation of such projects in healthcare institutions. Implementation is obviously one of the problems surrounding IS and especially CPOE; support on the basis of a valid implementation framework would be most welcome.

Objective
Finding a detailed framework, methodology or strategy that is universally applicable and offers maximum chances of successful implementation of a CPOE system in a hospital. Perform a validation of this framework based on experience of CPOE implementation in Thun hospital, which is considered to be successful.

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Methods and materials

A literature search was performed on PubMed for publications on implementation strategies for information systems. The chosen search strategies resulted in 68 different publications. Articles reporting the effects (success or failure of surrogate markers, organisational development after implementation) of an already implemented CPOE system (e.g. error reduction rate after implementing a CPOE system) were excluded if the implementation phase was not considered in the article. Methods for evaluation of running systems (e.g. comparison pre- and post-implementation) were also excluded, since their primary focus is not on factors influencing successful implementation. Out of the remaining articles, only two [10, 11] offer a structured and universally applicable framework. Both publications split the items influencing success and failure into 10 to 12 dimensions. Only one publication [11] is universally applicable for other than CPOE systems, and is thus chosen as main reference for the purpose of this article.

This work by Brender et al. proposes a framework for successful implementation of information systems in healthcare. The framework is the result of a Delphi Study design. 110 success and 27 failure items were identified and rated with regard to different IS types: administrative, production support, clinical, decision support and educational / training systems.

Validation methodology of a given framework

To validate the framework, only items and ratings of clinical systems and decision support systems are further followed, in contrast to the remaining three system types. Eight expert groups in the Delphi analysis rated each item as “not really important”, “sometimes important”, “important”, “central” or “essential”. For the purpose of this study, only items where at least 3 out of 8 expert groups rated at least “important” were included. With this limitation, 94 out of 110 success items and 17 out of 27 failure items are included in this study.

To render a comparison between the proposed framework and the real setting measurable, all success and failure items are weighted as the product of rating and fulfillment. Fulfillment of an item is for this purpose defined as a factor of 1 (totally fulfilled), 0.5 (partially fulfilled) or 0 (not fulfilled at all).

Adjusted weight = rating × fulfillment (e.g. adjusted weight = 4 × 1 = 4)

In this example, a factor rated as a 4 (= 4 experts) that is totally fulfilled in the implementation thus leads to an adjusted weight of 4. In the ideal setting, all items are totally fulfilled, resulting in the maximum of 411 points.

As the second part of the analysis we identified items which were important in our local settings with regard to the success of implementation, but which did not exist in the framework.

Results

The results of the validation are given in table 1 (success factors) and table 2 (failure factors) respectively. Of 411 weighted success points, our implementation achieved 336 points (82%). Out of 64 identified failure points, we could not avoid 12.5 points (19%).
Absent success and failure factors: the Thun experiences

Missing points from the Thun hospital viewpoint were also analysed. The most important points are – grouped by category – shown in table 3.

Table 3
According to the analysis of the framework by Brender et al., we identified distinct success and failure factors as especially important in our setting. The items are grouped by categories corresponding to the framework.

<table>
<thead>
<tr>
<th>Category</th>
<th>Thun experiences, missing items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional (success points)</td>
<td>The integral, interdisciplinary solution/incentives for every professional group using the system. ICT as enabler: no workflows had to be changed due to limitations of the ICT solution. Wireless LAN as enabler for ubiquitous information availability was essential. Perceived usefulness: solutions mainly perceived as useful are off-floor ordering, preadmission sets, department order sets [11].</td>
</tr>
<tr>
<td>Functional (failure points)</td>
<td>Inability to represent the detailed needs of daily practice in a commercial CPOE system.</td>
</tr>
<tr>
<td>Organisational (success points)</td>
<td>Choice of the setting: no introduction in ICU and ER (cave: transfers!). Choice of the POE part to introduce first is crucial: medication is extremely interdisciplinary.</td>
</tr>
<tr>
<td>Behavioural (success points)</td>
<td>Bringing the different user groups together. Flexibility: nurses can enter orders they receive by phone or by taking drugs out of the AMDS. New ways of communication: e-mail-like patient oriented mailing system within the PCIS serves for asynchronous tasks.</td>
</tr>
<tr>
<td>Behavioural (failure points)</td>
<td>Flexibility is abused mainly by physicians. Underestimation of power: nurses refuse patient transfers when orders are incomplete.</td>
</tr>
<tr>
<td>Cultural factors</td>
<td>Key people on both sides (medical informationists)</td>
</tr>
<tr>
<td>Political factors</td>
<td>Commitment from the clinical leaders (physician-in-chief)</td>
</tr>
<tr>
<td>Management factors</td>
<td>Mix of top-down decision to implement such a system and bottom-up decision to design and implement the system is crucial. Pointing out for each group arguments in favour of using the system: nurses, pharmacist and physicians all have other areas in which to profit from a code of use for the system. Key competences should be in-house.</td>
</tr>
<tr>
<td>Technical factors</td>
<td>Immediate feeling of security concerning availability and accessibility of the CPOE system is very important.</td>
</tr>
</tbody>
</table>

Discussion

Implementation of computerised support in clinical settings is known to be problematic. The intertwining of technical solutions with the behaviour of the users within institutions has led to the socio-technical approach in analysing problems and situations during implementation phases in healthcare institutions. In most publications we find similar dimensions of interest where special attention has to be given to: knowledge base and understanding of work, organisational aspects including internal and external fit, key people and users as key elements, usability and suitability of the information system, design and implementation. Given this complexity, it is hard to find a single list of relevant factors. There does not seem to be a unique formula with which success could be guaranteed.

Nevertheless, the framework of Brender et al. attempts to offer a globally applicable list of distinct success and failure points for implementation of IS in healthcare. For the retrospective analysis in our setting, 94 out of 110 success items and 17 out of 27 failure items were analysed. As the importance of each item is not equally rated by the experts, we calculated an adjusted weight by multiplying a factor of fulfillment with the number of experts rating the item. Thus a maximum of 411 success points and a maximum of 64 failure points are possible. Out of these points 82% of the success points were achieved in our hospital and only 20% of the failure points were incurred (table 1, 2). In summary, most of the relevant and usable (concerning sample size) items were fulfilled in 80–100%.

The framework was analysed for points lacking, meaning items that we would address as being our success and failure factors but that were not also considered in the framework. Although the framework covers many items, a considerable list of important points were identified during our retrospective analysis (table 3). This emphasises the difficulty of creating a definitive list of items to be considered on the one hand, and demonstrates the (needed) individuality of implementation on the other. Most of all, integration of the CPOE solution within the PCIS was crucial in our setting. Only full integration of the ICT system offers maximum advantage in usability and workflow improvement, being measurable in working time reductions for several professions! Compiling and listing the discharge medication based on structured data from admission to discharge, e.g. combined with the electronic transfer of this medication list to the pharmacy, where validation and delivery of drugs takes place, offers huge benefits compared to the system used previously. Second, separating drug prescribing from other POE elements is in our experience very important as well. Needs for graphic representation of prescription information are totally different from other forms of ordering (administration several times a day during the stay, history in terms of the last days is essential etc.). The setting where the system was primarily introduced is also crucial. Resistance in the emergency department and the intensive care unit was assumed to be very high due to lack of a PCIS for nurses in the ICU and the huge percentage of outpatients in the ER.
In summary we can conclude that most of the relevant success factors offered in the framework were fulfilled and – in a moderate proportion – some of the failure factors could not be avoided. This means that in our case the framework offers a valid opportunity for planning of successful implementation. However, some points rated as important were not essential at all (especially the political and financial aspects), and some that are relevant from our point of view were lacking. Thus, some extensions of the framework should perhaps be carried out in a local setting. Nevertheless, although the table of nearly 150 factors seems to be not very practical, it contains most of the factors mentioned in previous studies and offers a usable framework with which to support successful implementation. Furthermore, the items are cited in a precise manner and thus universal application is possible. Nevertheless, unpredictable factors and factors that cannot be influenced may result in failed implementation even when all items mentioned in the framework were followed. This retrospective analysis has several limitations. First, it is possible that such a framework, based on a Delphi study, cannot be validated by analysing existing systems at all. Second, although we consider our implementation of a CPOE system a success, this could be a misinterpretation. Third, although nearly all relevant points (success and failure) were considered, the simple multiplication of points and fulfillment resulting in a weighted sum may be wrong. Fourth, we cannot identify a valid cutoff identifying the application of the framework as successful. In addition, the rating of fulfillment by the author, emphasised by the judgement of two other persons involved in the project, could be prone to bias and should ideally be made in a broader setting. Last but not least, our hospital – although a typical Swiss non-university hospital – may not be representative of other hospitals and this narrows the applicability of the results.

**Conclusion**

Success in implementation of IS is a multidimensional process. There is no simple formula that could guarantee success. Despite cultural and social differences between the countries of the western world, some key points defining success or failure will nevertheless be the same. The framework proposed by Brender et al. offers a list of more than a hundred success and failure factors in twelve different dimensions. As shown in an “a posteriori” validation in a successful CPOE implementation in the hospital of Thun, the framework could be used for future implementations and should at least be such as to increase the chances of success. Further validation of the framework would emphasise its importance and its correctness. In the light of our experience, building an integral solution, designing CPOE with regard to the items ordered (treat medication POE separately), creating a code of use, creating technical reliability and mixing the top-down strategy with bottom-up implementation would be the most important factors in completing the framework.

Even if not every item of the framework is considered, it would be most important for future implementations to analyse and plan in depth, to recognise the socio-technical and user-centred aspects as very if not most important, and to aim for systems that fit as well as possible into a given health environment.

**References**