A combined disease management and process modeling approach for assessing and improving care processes: a fall management case-study

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Abstract: 275
Manuscript word count: 3500
Number of tables: 2
Number of figures: 3

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Key words: Process modeling; Disease Management; Healthcare process assessment; Quality of care evaluation.
Abstract

Objectives

To propose a combined disease management and process modeling approach for evaluating and improving care processes, and demonstrate its usability and usefulness in a real-world fall management case study.

Methods

We identified essential Disease Management related concepts and mapped them into explicit questions meant to expose areas for improvement in the respective care processes. We applied the disease management oriented questions to a process model of a comprehensive real world fall prevention and treatment program covering primary and secondary care. We relied on interviews and observations to complete the process models, which were captured in UML activity diagrams. A preliminary evaluation of the usability of our approach by gauging the experience of the modeler and an external validator was conducted, and the usefulness of the method was evaluated by gathering feedback from stakeholders at an invitational conference of 75 attendees.

Results

The process model of the fall management program was organized around the clinical tasks of case finding, risk profiling, decision making, coordination and interventions. Applying the disease management questions to the process models exposed weaknesses in the process including: absence of program ownership, under-detection of falls in primary care, and lack of efficient communication among stakeholders due to missing awareness about other stakeholders’ workflow.

The modelers experienced the approach as usable and the attendees of the invitational conference found the analysis results to be valid.
Conclusions

The proposed disease management view of process modeling was usable and useful for systematically identifying areas of improvement in a fall management program. Although specifically applied to fall management, we believe our case study is characteristic of various disease management settings, suggesting the wider applicability of the approach.
Introduction

Process modeling (PM)

A process is a series of activities, for example a business process is a set of business activities that are ordered according to a set of procedural rules with service delivery as its goal. A model of a (business) process describes, often diagrammatically, how components in that process work and collaborate together; it provides a high level specification of processes that is independent of any management system [1]. An important objective of a process model is its applicability as a conceptual construct for better understanding and communicating about the components of the underlying process. Sometimes it is also used for inference, for example to simulate the process under various conditions or to redesign the process to improve its efficiency or feasibility.

Among the various approaches to process modeling, object oriented (OO) methods are particularly popular [1, 2]. The Unified Modeling Language (UML) is an important OO modeling standard and consists of a language for specifying, visualizing, constructing and documenting software and non-software artifacts [3]. UML is a composite of various diagram types for static and dynamic models. The static diagrams show the underlying structure of a system (such as the components and structure of an organization). The dynamic diagrams capture the behavior and interactions of the components in a system. Central to process description in UML is the concept of activity [2, 4]. The activity diagram offers comprehensive support for the workflow (process flow) and data perspectives, allowing the majority of the constructs encountered when analyzing this perspective to be directly captured [2, 3]. Therefore we used the UML activity diagram (UML-AD) to represent sequences of actions for this study. Although process modeling has been widely applied to branches such as industry, it has also been recently applied to health care [5-8]. An example of the application
of UML (activity, use-case, and class diagrams) in health care is the visualization of the hospital-based cancer registration processes by Shiki et al. [5]. The approach in this work is valuable because it demonstrates how systematically modeling and visualizing the core activities, information flows, and the staff involved had contributed to a comprehensive understanding of how (cancer) registries work.

Current work in process modeling focuses on how to describe and visualize processes systematically. However, there is little uniformity on how to use these models for quality assessment of the underlying processes, especially when it comes to emerging health care provision strategies.

**Disease management (DM)**

According to the Care Continuum Alliance (CCA) (formerly Disease Management Association of America, DMAA), disease management is a system of coordinated health care interventions and communications for populations with conditions in which patient self-care efforts are significant [9]. DM is a strategy aimed at providing efficient and effective care for patients, especially to those patients suffering from chronic conditions [10]. The goal of disease management is to provide effective and efficient care to a specific patient group by, among other things, improving the involvement of the patient, task transfer of (collaborative) work (for example from specialist to general practitioner), and the use of scientific evidence in clinical practice [11, 12]. In Europe, increasingly more hospitals and other local care organizations practice their own disease management programs at the micro level, which have been successful. These programs should be emulated in full delivery systems, to realize these same advantages on a larger scale [13].

The CCA lists the following components of full-service disease management:

- Population identification processes;
- Evidence-based practice guidelines;
• Collaborative practice models to include physician and support-service providers;
• Patient self-management education (may include primary prevention, behavior modification programs, and compliance/surveillance);
• Process and outcomes measurement, evaluation, and management;
• Routine reporting/feedback loop (may include communication with patient, physician, health plan and ancillary providers, and practice profiling).

DM essentially consists of desiderata that the provided care should meet. Evaluations of the disease management programs are often methodologically difficult [12, 14]. DM does not provide a systematic link between these desiderata and pre-specified properties of the underlying health care provision. This impedes assessment of the extent to which an already implemented health care program is DM-compliant, and in turn, misses opportunities to systematically improve components or the whole program by increasing its compliance to DM requirements.

There are relevant attempts at assessing the effectiveness of integrated care programs, for example, those based on elements of the Chronic Care Model (CCM) [15]. CCM is an evidence based conceptual model developed by Wagner et al. in 2001 [16] for care delivery to chronic care patients. Although CCM and DM use or emphasize different components [12], they do share many objectives such as the need to manage increasingly complex multidisciplinary care for chronic patients. The following concepts in CCM are already addressed in DM: “patient education”, “guideline use”, “information systems”, and “personnel type”. There is also clear overlap in the concepts “system delivery design” and “self-management” in both CCM and DM. In contrast, the concept of “provider education” from CCM is not addressed explicitly in DM. Like DM, CCM lacks a systematic link between its desiderata and assessment of the underlying health care provision. Therefore, in their study [15] Wagner et al. designed a short survey to enquire about the implementation state of CCM.
concepts for health care programs. The survey was then applied to chronic care management programs using interviews and site visits [15]. The topics of the survey are stated at a high level of abstraction making it useful to globally characterize and assess a large number of care programs. The survey topics are however not geared toward a detailed assessment for a particular care program.

Another work suggested the Development Model for Integrated Care (DMIC), which described nine clusters of 89 elements that are thought to contribute to the integration of care [17]. This framework overlaps with DM and CCM and is more detailed than both, but like DM and CCM it does not exploit process models for assessing the care programs.

Hence, in spite of efforts toward standardizing measurement and evaluation of DM principles or other evaluation and improvement methods [14, 15, 18], no attempts were made to combine process modeling and structured desiderata to assess the quality of care programs and identify areas for improvement.

**Aim**

The aim of this paper was to propose and evaluate a combined approach of DM and PM in which process models constitute an important link between the DM desiderata and the health care program.

Specifically, we propose in this paper a combined PM- and DM-oriented approach in which process models are viewed and systematically assessed from a DM perspective. This DM perspective is represented by a series of questions, distilled from the DM desiderata that analysts need to address. We aim to demonstrate the usability and usefulness of this approach to a real-world fall management case-study. Our approach is meant to contribute to PM methodology by enriching it with an accessible procedural method for examining processes of disease management programs, and to the analysis and improvement of other specific disease management programs by the application of this approach.
Case study: fall-management

To illustrate our approach, we apply it to a case study of a fall prevention program. Falls in elderly persons form an important societal problem and a major public health concern [19-21]. This is of particular concern in western countries such as the Netherlands due to the increasing number of persons aged 65 years and older (increase from 2.15 million in 2000 to 2.72 million in 2012). The increase in the number of persons of 80 years and older is even sharper, comprising a 37% increase from 500,339 in 2000 to 686,015 in 2012 [22]. Annually, about 30% of the community-dwelling persons aged 65 years and older fall once, and around 15% fall twice or more [19, 20]. The high incidence and severe consequences of falls underlie the need for primary and secondary preventive measures. Although an increased fall risk is not a disease, management of all risk factors contributing to the fall risk shares many characteristics of disease management in terms of focusing on a specific subpopulation, having a population-based approach to identify persons at risk, intervening with specific programs of care, shared care, and measuring clinical and other outcomes. There are some initiatives addressing the process of fall prevention programs, but focusing on only specific aspects such the information infrastructure underlying the process [23, 24]. There is hence still a need for systematic methods for integrally describing, evaluating and improving the process of fall prevention and management.

Our case study involves a homecare organization, six primary care practices, and two departments of a tertiary university teaching hospital, the Amsterdam Academic Medical Center: an emergency department and a dedicated (secondary) fall prevention outpatient clinic. The fall-management program was set up as a cooperative effort to coordinate care for fall-prone patients between these facilities. Representatives from all stakeholders, including nurses specialized in falls, primary care physicians, geriatricians and other clinicians, and managers participated in the study. Although patients are also stake-holders in this case-study,
we did not involve them yet because the focus was mainly on the characteristics of the process of provided care. Patients’ involvement would be especially beneficial in addressing in-depth quality assessment such as the questions stated in the last column of table 1.

*Short description of the current fall management program:*

There are two recruitment options for entry into the fall management program: patients who are included in the program by the Emergency Department after a fall and those included by the homecare organization or a general practitioner.

Patients included by the Emergency Department receive an assessment of fall history (by post) using a self-assessment questionnaire, followed by a treatment plan which may include a referral to the outpatient fall clinic.

Homecare nurses routinely screen new clients who are older than 65 years for fall risk. If there is an increased risk of falling, a home management program is started including self management, checking the patient's medication, and checking the home for safety after receiving permission from the general practitioner (GP). Up to four visits of a homecare nurse with the patient may be scheduled. A brief report on the patient-specific program is sent to the general practitioner at the end of all the home visits. The general practitioner may also initiate the fall prevention program by referring patients perceived as at-risk to the hospital's outpatient fall clinic or to the homecare organization.
Methods

Our approach combines process modeling with the principles of disease management (DM). The desiderata of disease management are reformulated as questions, which are applied to a process model to allow verification of the disease management criteria. This process is illustrated in the real-world case study of fall management described earlier. The steps in the process of developing and validating our approach are as follows:

- Formulating DM related concepts as questions
  o Requirements for questions about a DM concept
  o Question derivation
- Modeling the health care processes and applying the DM questions in the case-study
- Validation of the fall management case-study results and the approach
  o Gauging the experience of the modeler: usability of the method
  o Validating the correctness and prioritizing the findings: the usefulness of the approach
  o Gauging the experience of an external validator without the knowledge of interviews.

We address below each of these steps.

Formulating DM related concepts as questions

Using the criteria of CCA for DM, an expert panel of 4 medical informaticians and 2 physicians proposed questions and critiqued them in several rounds until consensus was reached. The panel translated each concept into two sets of questions: the first set of questions was meant to assess whether that concept is realized in the processes.
The second set of questions consisted of detailed questions to quantify the concept in the first set. For example, if in the first set we ask whether there is a mechanism to register sensitivity of an instrument then in the second set we would ask how sensitive the instrument is. While the first set addresses the structure of the provided care process, the second addresses performance-related aspects of the care process. [Table 1, column 2 and 3].

*Requirements for questions about a DM concept*

Questions in the first set were considered to be answerable dichotomously. Our panel formulated the questions related to each concept requiring that a question should either:

- Verify the availability of a **mechanism** for the realization of the DM concept in the process (e.g. existence of a mechanism for population identification), or
- Assess the quality of the implementation of the DM concept. For example we may ask whether there are mechanisms to obtain the **sensitivity** and **specificity** of the population identification).

Questions in the second set quantify the concept in the process and therefore may be numeric or open-ended.

*Question derivation*

The general procedure to design the questions was based on identifying (a) the underlying sub-process of a DM criterion, (b) the relevant attributes of the sub-process elements, and (c) the mechanisms through which the sub-process is operationalized.

To illustrate this procedure we give an example of the DM criterion “Population identification process” which is aimed at testing whether an individual belongs to the target DM group. The panel viewed this criterion as a **sub-process** in which there are **individuals** taking a **test**. For **test** the panel suggested **attributes** of a generic test such as cost, sensitivity, specificity, pass, fail, administration etc. Questions related to relevant attributes and mechanisms pertaining to the sub-process and attributes of its elements were then captured in the framework. For
example, the panel looked at the mechanism that operationalizes the sub-process: is there a mechanism, and how is it implemented, to verify membership to the target group (e.g. enquiry by mail or computerized questionnaire). Considering the attributes of test such as sensitivity, specificity and fail give rise to questions such as “Is there a mechanism to obtain the sensitivity and specificity of the screening instrument within the subpopulation?" and “Is there an administrative system for tracing the subjects that refuse to participate or subjects that test negatively at this moment of population identification?" Answering these questions in a structured manner aided assessing the quality of the process and of its improvement.

Table 1, which presents the main result of this first step, shows the DM criteria, a brief description, the key questions, and examples of questions related to quantitative assessment and quality improvement.

**Modeling the health care processes and applying the DM questions in the case-study**

The purpose of a care process model can be to explain the process to stakeholders as well as to facilitate analysis. A recent review of business process modeling techniques suggested the UML activity diagram as one of the best choices for achieving these goals [2]. We obtained process models by having a modeler perform (semi-structured) interviews with stakeholders to recognize essential sub-processes with special focus on workflows, information/data sources involved, and organizational aspects (such as organizational boundaries). In applying this approach to our case study we used an adapted UML-AD 2.0 for the activity diagrams, where the modeler used UML’s “swimlanes” and paid specific attention to identifying information sources used in the processes. Swimlanes in UML are lines, often vertical, which visually distinguish responsibilities or roles in processes. For example, modeling a physician interacting with a patient requires two lanes, one for each. We paid specific attention to
identifying information sources used in the processes. After drafting, the UML models were reviewed by the stakeholders. Areas for improving the process were identified by addressing the DM questions related to the process model.

**Validation of the fall management case-study results and the approach**

This step consists of the following three sub-steps.

1) **Gauging the experience of the modeler: usability of the method**

To assess the usability of applying the approach as such to the case-study we interviewed the modeler. The assessment focused on the ease and ability of the modeler to express the process as he perceived it and to apply the questions to the process model. We asked the modeler two specific questions: (1) whether the approach allowed for expressing what he wanted to state and (2) whether and where he encountered difficulties in the modeling process.

2) **Validating the correctness and prioritizing the findings: the usefulness of the approach**

In an invitational symposium of 75 attendees and a panel of 9 experts, the stakeholders and other relevant interested parties (consisting of general practitioners, homecare employees, nurses and geriatricians) validated the results pertaining to the fall management case-study. The results were presented to the attendees, who were asked to assess the correctness of the problems presented and prioritize their importance. The second set of questions was used to quantify the problems and find improvement solutions.

3) **Gauging the experience of an external validator without the knowledge of interviews**

In addition to the experience of modeler, an external validator assessed the process of fall management using only the UML activity diagrams and the DM questions without having the knowledge that was gained during the interviews. The validator was blinded to the interviews and the modeling process itself.
Table 1: DM concepts and related key questions for evaluating the care processes.
<table>
<thead>
<tr>
<th>DM</th>
<th>Interpretation</th>
<th>Questions</th>
<th>Examples of assessment and quality improvement questions</th>
</tr>
</thead>
</table>
| Population identification processes | There exists a specific patient population and a corresponding mechanism for its identification. | - Is there a population **identification** mechanism that identifies members of this population?  
- Is there a mechanism to obtain the **sensitivity and specificity** of the screening instrument within the subpopulation?  
- Is there an administrative system for **tracing** the subjects that refuse to participate or subjects that test negatively at the moment of population identification?  
- Is there any mechanism to find the **reasons for refusing** the test?  
- To what extent does the identification process tax the subjects?  
- What is the sensitivity and specificity of the screening instrument? | |
| Evidence-based practice guidelines | Use of evidence based guidelines and practicing evidence-based medicine. | - Are there evidence-based **guidelines** available at the decision making moments?  
- Is there a **maintenance** mechanism within the current processes for evidence based guidelines?  
- Is there a mechanism to measure the **agreement** on the whole or part of the guideline(s)?  
- Is there a **computerized decision support system** (CDSS), providing feedback such as alerts or reminders, available at the decision making moments?  
- What is the level of adherence to guidelines?  
- To which degree do the people responsible for following the guideline agree with the whole or part of the guideline(s)?  
- Where in the process can guideline based decision support be used? | |
| Collaborative practice models to include physician and support-service providers | Collaborative models in which all the participants link/share the community resources inside and outside of the organization. | - Are there defined **roles**, including protocols, among participants? Is there an explicit process owner?  
- Is there a system delivering/explaining the type of **services** provided by other participants in the program?  
- Is there a mechanism to introduce and facilitate the use of a partner’s **resources**?  
- Are stakeholders aware of their partners?  
- How optimal is the use of other resources? | |
| Patient self-management and education | Involves primary prevention, behavior modification programs, and compliance/surveillance | - Is there a patient **self-management** program (e.g., primary prevention program) available?  
- Is there a mechanism to **motivate** the patient to attend the program?  
- Is there a mechanism to assess the patient's **knowledge and capabilities** in order to adapt the self-management education program to provide tailored information?  
- Is there a program for **continuous education**?  
- Is the self-management program aligned with the goals of the program?  
- Is the patient empowered for her/his crucial role in maintaining his/her health? If not, how should empowerment be promoted?  
- What is the effect of the self-management education on (e.g.) awareness, knowledge, behavior of the patient and patient outcomes? |
| --- | --- | --- |
| Process and outcomes measurement, evaluation, and management | Includes evaluations of the processes, and outcome measurement | - Are (key) process and outcome **quality indicators** defined?  
- Is there a mechanism to **register** the (key) quality indicators and outcome?  
- Is there a mechanism to **evaluate** the quality of care based on the indicators?  
- Is there a **continuous** monitoring mechanism available?  
- Is there a mechanism for **acting** upon the (key) quality indicators?  
- Are the (key) quality indicators defined according to explicit criteria? |
| Routine reporting/feedback loop to individuals participating in the process (patient, physician, etc.) | Includes communication with patient, physician, health plan and other providers, and practice profiling | - Is there a mechanism to **report** to the stakeholders including the process owner?  
- Are there **report templates** for the individual participants?  
- Where can technology, such as IT, be used for feedback and reporting?  
- How should a routine reporting/feedback loop be generated? |
Results: application of the approach to the case-study

The process models revealed that care activities, in the primary as well as the hospital care, could be adequately categorized in a pattern of five steps as illustrated in Figure 1.

**Figure 1: Generic profiling process for fall risk assessment and management**

- **Case finding:** This step selects patients that might be at elevated risk of falling.
- **Risk profiling:** This step sets up a patient-specific fall risk profile based on additional information, such as identified risk factors pertaining to falls.
- **Decision making:** In this step decisions are made that determine the patient’s treatment plan.
- **Coordination:** In this step interventions are planned and consultations scheduled to realize the treatment plan.
- **Interventions:** In this step diagnostic and (preventive) treatment procedures are performed.

After drafting the process model in the activity diagrams for all stakeholders in the program, we applied the DM questions to the model. The bottlenecks were identified based on answering the DM questions in each stakeholder’s process model, and are represented by the label ‘<<bottleneck>>’ in the model diagram. An example activity diagram showing the process followed at the homecare organization, including the steps in the process, activities,
and bottlenecks, is presented in figures 2 and 3. In Figure 2, in the swimlane of the BackofficeEmployee, we encounter at the bottom left the subprocess “GP notification,” which refers to notifying the GP about patients that are not motivated to take the homecare fall prevention program but are at high risk of falling. The bottleneck box associated with this subprocess states that homecare does not have an administrative system to keep track of these patients and therefore that the organization cannot measure the sensitivity and specificity of their triage instrument.

The results of the application of the DM questions to all of the fall management care processes are presented in table 2. An answer of “no” to any of the DM questions indicates an area for improvement. When the modeler could not find the answers from the models with the knowledge gained during the interviews, an answer of “no” was assigned. For example: in Figure 3, part P1.5: There is no mechanism to assess the patient’s knowledge and capabilities in order to adapt the self-management education program, so the answer to the question “Is there a mechanism to assess the patient’s knowledge and capabilities in order to adapt the self-management education program to provide tailored information?” will be “no.”
Results of the validation of the approach

Gauging the experience of the modeler: usability of the method

We interviewed the modeler for a preliminary (subjective) assessment of the usability of the approach. The modeler reported that the UML activity diagram could easily capture the process activities as expressed by the stakeholders including the flow and presence of the concepts/activities and flow of the data. He however reported that organizational aspects were harder to capture and therefore extracting these data needed extra interviews and efforts.

Validating the correctness and prioritizing the findings: the usefulness of the approach

In the symposium the attendees were asked to comment on the correctness of the findings. The findings were communicated with the audience through a large projector showing the process models, presented per organization and as a whole. The bottlenecks were mapped on the process models. The attendees were (plenarily) invited to comment on each set of findings and on the final set of findings of the whole program. The attendees agreed on all items of the problem list and the need to address them. They offered additional suggestions for improvements. In addition, they were asked to prioritize the findings for implementation. Some of the identified bottlenecks were not considered a top priority for improvement, but others were designated as key improvement findings. For example, introducing a computerized decision support system (CDSS) in homecare was acknowledged as an improvement but was not designated a high priority. In contrast, finding a good solution for general practitioners (GPs) for systematically identifying patients at high risk of falling was assigned high priority, and decision support in the GP setting was considered an appropriate tool to achieve this goal. The attendees also indicated that having a clear definition of the roles and follow-up procedures for the GPs was considered a key improvement action. In
addition, the GP was thought to be a suitable process manager for monitoring the follow-up procedures.

The application of our approach led to solution proposals. As an example, the introduction of CDSS also facilitates the automation of key quality indicator monitoring and reporting. In addition, solutions for empowering elderly patients included employment of web-engineering to develop useful websites for continued and tailored education, for example to help them prepare their visit to the GP or to understand how to prevent a second fall.

_Gauging the experience of an external validator without the knowledge of interviews_

To assess whether the process model and DM questions could be used to identify problem areas without additional knowledge of the process, the questions were separately applied to the process model by an external validator who had not participated in the interviews or modeling process. The external validator was less able to apply all the questions to the processes. The validator was able to answer 11 out of 22 (50%) of the questions using the process model alone. In particular, the validator found that it was difficult to distinguish omissions in the real-world process from omissions in the model. For example, one can not tell by inspecting the diagram whether the screening instrument used had an adequate sensitivity and specificity.
Figure 2: The case finding step in homecare fall prevention program: The intaker decides based on three screening questions whether further intervention is required to reduce the risk of falling. After authorization by the GP, up to four home visit sessions will be initiated.

GP: general practitioner; EPR: electronic patient record; PPR: paper-based patient record system. AC stands for the home care organization, and the number indicates the form type used (including medium (digital, paper)). The different intensities of gray indicate the location of the activities: dark gray indicates nurse office, lighter gray indicates the patient’s home and no color indicates the back-office. Swimlanes show the actors of the activities. Transitions (fork, join) indicate the division of an action state into multiple parallel states or merging several action states together.
P1.2 Risk profile; P1.3 decision making; P1.4 Coordination; P1.5 Intervention

Figure 3: Processes of risk profiling and fall prevention intervention in home care, the second to fifth steps.

GP: general practitioner; EPR: electronic patient records;
Table 2: Result of the final analysis based on the whole fall management program

<table>
<thead>
<tr>
<th>DM concepts</th>
<th>Questions</th>
<th>Application by the modeler</th>
<th>Application by the external validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population identification processes</td>
<td>• Is there a population identification mechanism that identifies members of this population?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>• Is there a mechanism to obtain the sensitivity and specificity of the screening instrument within the population?</td>
<td>No</td>
<td>Not able to answer</td>
</tr>
<tr>
<td></td>
<td>• Is there an administrative system for tracing the subjects that refuse to participate or subjects that test negatively at the moment of population identification?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>• Is there any mechanism to find the reasons for refusing the test?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Evidence-based practice guidelines</td>
<td>• Are there evidence-based guidelines available at the decision making moments?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>• Is there a maintenance mechanism within the current processes for evidence based guidelines?</td>
<td>No</td>
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<td></td>
<td>• Is there a mechanism to measure the agreement on the whole or part of the guideline(s)?</td>
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<td>No</td>
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<td></td>
<td>• Is there a computerized decision support system (CDSS), providing feedback such as alerts or reminders, available at the decision making moments?</td>
<td>No</td>
<td>Not able to answer</td>
</tr>
<tr>
<td>Collaborative practice models to include physician and support-service providers</td>
<td>• Are there defined roles, including protocols, among participants? Is there an explicit process owner?</td>
<td>No</td>
<td>Not able to answer</td>
</tr>
<tr>
<td></td>
<td>• Is there a system delivering/explaining the type of services provided by other participants in the program?</td>
<td>Not completely</td>
<td>Not able to answer</td>
</tr>
<tr>
<td></td>
<td>• Is there a mechanism to introduce and facilitate the use of a partner’s resources?</td>
<td>Not completely</td>
<td>No</td>
</tr>
<tr>
<td>Patient self-management education</td>
<td>• Is there a patient self-management program (e.g. primary prevention program) available?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>• Is there a mechanism to motivate the patient to attend the program?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>• Is there a mechanism to assess the patient’s knowledge and capabilities in order to adapt the self-management education program to provide tailored information?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>• Is there a program for continuous education?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Process and outcomes measurement, evaluation, and management</td>
<td>• Are (key) process and outcome quality indicators defined?</td>
<td>Not completely</td>
<td>Not able to answer</td>
</tr>
<tr>
<td></td>
<td>• Is there a mechanism to register the (key) quality indicators and outcome?</td>
<td>No</td>
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<tr>
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<td>• Is there a mechanism to evaluate the quality of care based on the indicators?</td>
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<td>• Is there a mechanism for acting upon the (key) quality indicators?</td>
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<tr>
<td>Routine reporting/feedback loop to individuals participating in the process (patient, physician, etc.)</td>
<td>• Is there a mechanism to report to the stakeholders including the process owner?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>• Are there report templates for the individual participants?</td>
<td>Yes</td>
<td>Not able to answer</td>
</tr>
</tbody>
</table>

*: the result of the application of the framework to the fall prevention processes during the process modeling development by the modeler.

#: testing the capability of the model without knowledge that was captured from the interviews by the external modeler.
Discussion

We proposed a systematic approach to assess and improve a healthcare program in which process models are evaluated by a set of disease management criteria, cast as applicable questions. The application of this approach to an extensive fall management program involving different partners from primary and secondary care demonstrated the feasibility of this approach.

This is the first approach suggesting and applying the combination of DM and process modeling to evaluate health care processes. This approach is not only relevant to DM but also to other related approaches such as the chronic care model (CCM) and the Development Model for Integrated Care (IDMC). For example, to extend our approach to accommodate CCM one should add questions such as: “is there a mechanism for educating the stakeholders?” and; “is there a mechanism to test the stakeholder’s knowledge?”.

The UML activity diagram seems to offer adequate expressivity to represent activity and data flows that the modeler intended to model. Although the validator was able to answer many questions correctly based on the process model, there is an opportunity for extending the activity diagram to specifically facilitate answering the questions after, instead of during, the modeling task without the knowledge that is gained during the interviews. In addition, in contrast to the control-flow dimension which activity diagrams can easily represent, it might be beneficial to extend these diagrams with notations or other diagrams that address the questions pertaining to the organizational aspects. This implies that stakeholders should also include those knowledgeable about the organizational dimensions.

Explicit process models also facilitate to some degree the independence between the roles of modeler and evaluator: The modeler is technically skilled in translating reality into a (semi-formal) model and the evaluator (e.g. someone from the quality and safety department or a
(manager) should be able to understand the model and apply the relevant questions to it. It is inevitable that health delivery will change over time and the process models need to be updated to keep up with these changes. Many changes, however, will be local in nature requiring only small incremental changes to the model and will probably necessitate re-applying only a small subset of the DM-related perspective.

A main strength of our approach is its capability of merging two disciplines: one for describing and visualizing processes and the other for stating desirable properties about these processes. This offers the opportunity to draw on what is already known in each discipline and augment it with its counterpart. In addition, the application of this approach helps to systematically identify solution proposals. Nevertheless, the suggested solutions still need to be implemented and their benefit should be tested in practice.

Although DM, and particularly the use of information technology in DM, is thought to be promising, there are no explicit procedural cues that help health IT design to capitalize on this promise. Our suggested approach allows analysts, designers, and maintainers of health care IT systems to systematically elucidate requirements design and sustain systems while (1) staying in agreement with DM principles and (2) using visual yet semi-formal models that support communication among stakeholders.

Our work has some limitations. First, our evaluation of the approach is preliminary: we worked with one, albeit complex, case study and one modeler at a time. Hence we do not know what the inter-rater agreement would have been if the evaluation had been conducted in parallel by another team or using a different approach. We also did not try the implied solutions in clinical practice. Second, although the identified weaknesses in the process were considered sound, the mapping between the DM categories and the questions is inherently subjective. We do not have a gold standard to assess the soundness and completeness of the questions, and hence it is possible that questions have been overlooked. We attempted to
formulate the questions at the most generic level possible, but the researchers were aware of the fall prevention at the time the questions were written. By the same token, formulating the model itself also resulted in the inclusion and adaptation of questions. Our questions may hence have a bias towards processes similar to our case study. We however believe that we propose a simple yet potentially useful approach, as demonstrated in our case study, for visualizing and structuring the evaluation of the clinical processes and focusing discussion about a DM program.

Further research includes comparing results obtained by our approach with those obtained without it, applications of the approach to other domains and testing whether the set of questions needs adaptation, and measuring the inter-rater reliability by repeating the evaluation by extra observers and assessing the usefulness of the proposed solutions.

**Conclusion**

We anticipate that our approach will be useful to others who wish to identify shortcomings in complex care processes and contribute to a meaningful discussion about a DM program. At a minimum, the approach’s value stems from its systematic checklist nature, guiding interviews and facilitating the modeling task to capture richer process models.
Funding

This research was partly funded by ZonMw (The Netherlands Organization for Health Research and Development) by grants for the PROFIT (#300020010) and ICOVE (#311020302) projects.
References


