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An Application Meta-Model for Community Care

Pilar Mata^a, Aladdin H. Baarah^b, Craig Kuziemsy^c, Liam Peyton^{a,*}

^a*Faculty of Engineering, University of Ottawa, 800 King Edward Avenue, Ottawa K1N 6N5, Canada*

^b*Hashemite University, Zarqa, Jordan*

^c*Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa K1N 6N5, Canada*

Abstract

Care process monitoring is needed to provide performance management reporting to measure how quality of care goals are being met for a specific care process. There are special challenges faced when monitoring community care processes, especially if one wants to manage performance for community care across an entire geographic region. In this paper, we evaluate an application meta-model for defining a care process monitoring application (CPMA) previously developed for monitoring care processes in a hospital, to determine its effectiveness for addressing community care processes. A case study developed in collaboration with a regional health authority is used.

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1. Introduction

Countries continue to spend large amounts of money on the adoption of health information technology (HIT) as a driver of healthcare reform¹. HIT has the potential to enhance healthcare delivery by improving efficiency and safety while supporting care delivery models such as continuity of care^{2,3}. HIT can be particularly helpful in community care where patients are seen in a variety of settings and providers⁴. Yet despite this promise, HIT mediated community based care has not reached the desired level of maturity. There is good progress at delivering care processes (i.e. assessments, treatments) but there is less progress at monitoring the delivery of the processes⁵. Care process monitoring is needed to provide analytics and performance management reports to measure how well we are meeting quality of care goals for a specific care process. In hospital based care delivery, clinical pathways or clinical practice guidelines can be used for process monitoring^{6,7} and the data that is needed for performance monitoring such as tracking referrals or access to services is typically available through an enterprise model. In¹⁵, we

* Corresponding author. Tel.: +1-613-562-5800x2122; fax: +1-613-562-5664; E-mail address: lpeyton@uottawa.ca

have articulated a methodology for the development of care process monitoring applications (CPMA) that collect data dynamically while a care process is taking place to monitor performance management goals.

Performance monitoring is far more difficult in the community due to several challenges including disparate data sources, undefined processes and system interoperability issues⁸. Given that increasingly more care is delivered across diverse community settings the importance of being able to monitor the accountability of community health organizations has been acknowledged^{9,10}. This paper addresses that need by using a case study of palliative care monitoring across an entire health region to evaluate a recently proposed application meta-model for care process monitoring¹⁶. In evaluating the proposed application meta-model we highlight differences between hospital-based care process monitoring with community-based. In the following sections we provide the background to our study, our application meta-model for care process monitoring, our case study of community care process monitoring of palliative care in the Greater Ottawa Region, and then an evaluation of the care process monitoring application meta-model. We conclude with implications and next steps arising from our research.

Nomenclature

HIT	Health Information Technology
LEAP	Learning Essential Approaches to Palliative and End of Life Care
PAL-IS	Palliative Care Information System
PM	Performance Management
CPMA	Care Process Monitoring Application

2. Background

We have been working since 2010 on the design of a Palliative Care Information System (PAL-IS). PAL-IS has been designed over three phases. Phase 1 was a complete palliative care electronic health record, used by a team of palliative care specialists that provided specialist services in support of family doctors, long term care facilities, retirement homes, etc. It supported symptom assessment and patient record management, care team coordination and reporting on education and care delivery^{8,11}. PAL-IS1 achieved its design objectives but faced process, data and technical interoperability issues¹¹. The major issue was that PAL-IS1 required too much data collection and there was a disconnect between the data collected and what was actually used to meet reporting requirements.

In Phase 2, to overcome the issues we changed our system design approach for PAL-IS2 by reinventing it as a CPMA that focused on maximizing the value of the performance management provided by reports while minimizing the data entry burden. In designing PAL-IS 2, we built an application model that linked goals and metrics to data-entry forms within the care process¹⁴. We first analysed the goals of the palliative care program and defined how outcomes would be measured. We then mapped outcomes to the processes involved in delivering care and identify the minimal dataset to be collected. To implement PAL-IS2 we developed an open source application framework called QuickForms¹⁴ that enabled rapid development and deployment of mobile business intelligence applications that directly linked forms to a metrics data mart for continuous reporting.

In Phase 3, we are looking to monitor the delivery of all palliative care across the entire health region, not just the care provided by a single team of specialists. In doing so, we have re-evaluated the application model used for PAL-IS2, that was based on an application meta-model developed primarily for hospital care monitoring¹⁶. A meta-model seeks to define a syntax and to develop a collection of classes to describe domain concepts¹². It was not clear that the application meta-model and approach used in PAL-IS2 would scale up when applied to PAL-IS3 to monitor all care providers in an entire health region. That was the focus for the case study in this paper.

3. Application Meta-Model for Developing Community Care Process Monitoring Applications

A care process monitoring application (CPMA) is a software application which collects data from various sources while a care process is being provided, in order to provide reporting of metrics that measure how well the performance goals for the process are being met¹⁶. The biggest challenge in engineering a CPMA is to understand what low level data should be collected at what point in the care process from what operational systems in order to compute which metrics. The application meta-model defines the information model that a CPMA maintains as performance management reports are generated from collected data while the care process is taking place. The application meta-model is used to define an application model to guide the design and implementation of a CPMA.

3.1. Application Meta-Model

As shown in Figure 1, the meta-model defines a care process monitoring application in terms of a process model, performance model and enterprise model. The process model defines the care process in terms of *States* to be monitored; *Resources* involved in the process (patients, nurses, doctors, rooms, devices); and *Rules* that specify the transition from state to state as data in the form of *Events* are received from information technology *Sources* as defined by the enterprise model. The performance model measures how well the *Goals* for the care process are being achieved in terms of *Metrics* computed from the monitored states and events for the process. *Alerts* are defined to flag when targets are not being met.

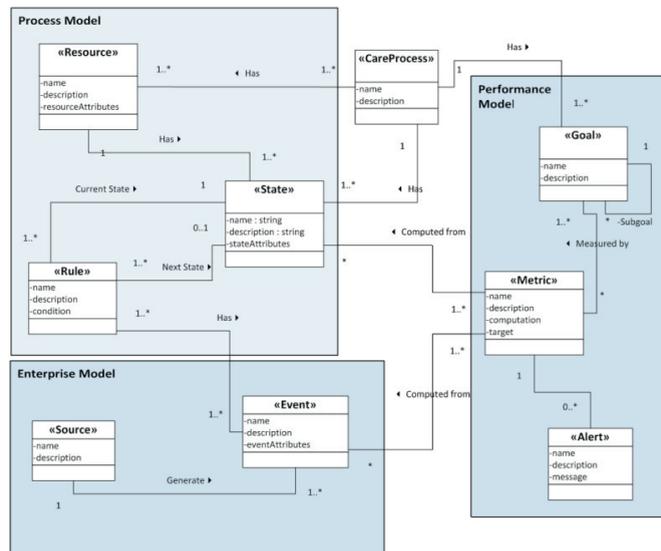


Fig.1 - Application Meta-Model

The application meta-model was originally developed for hospital care process monitoring with sophisticated information technology support, but it is intended to address community care process monitoring as well. Community care processes typically have simple forms rather than complex event-based technology, but the data collected by a form can be viewed as documenting an event. On the other hand, the coordination of resources from different organizations across an entire health region can be more complex than in a hospital. Especially, since community care processes are typically not as rigorously defined as clinical pathways in a hospital.

3.2. Development of a Care Process Monitoring Application

To develop a CPMA, the application developer requires detailed care process analysis to define the care process and its required performance in enough detail to give the application developer a foundation for the care and process

model aspects. The application developer also needs a detailed understanding, from an enterprise architect, of the enterprise information technology infrastructure that support the care process and which will provide the data used for monitoring. The developer then identifies the events and specifies the rules that will be used to collect the data for metrics reporting and alerts. Typically, in community care, a CPMA is built as a Mobile Forms application that can collect the required data for reporting. Figure 2 shows how we leverage the QuickForms Mobile applications in such cases. Each time a form is saved it corresponds to an event that is stored in the Metrics Data Mart. The data that is filled in for each field on that form corresponds either to a measure (e.g. duration, or weight) or to a dimensional lookup table (e.g. diagnosis, location). The fact tables and dimensional lookup tables of a metrics data mart are well-structured for reporting of metrics and alerts. The data can also be archived into a traditional data warehouse to incorporate historical data (to highlight trends or changes) into the performance reporting dashboard.

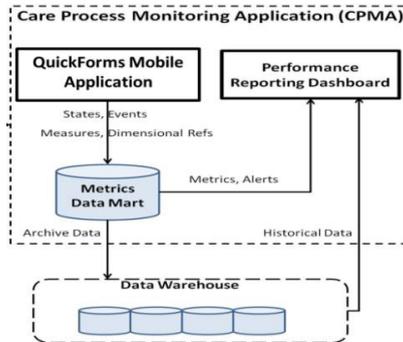


Fig. 2 - Care Process Monitoring Application Architecture

4. Case Study: Community Care Process Monitoring in the Ottawa Region.

Since 2012, we have been working with the Regional Standards and Indicators Specialty Committee responsible for the development and implementation of an accountable Palliative Care system across the Greater Ottawa Region. The committee developed a set of 22 metrics for three major PM goals: Access, Education and Care. The Access goal is to ensure all palliative patients are identified and referred to palliative care services. The Education goal is to ensure care providers in the region have a basic level of palliative care training called LEAP (Learning Essential Approaches to Palliative and End of Life Care). Finally, the Care goal is to ensure patients spend their last days with appropriate pain and symptom management, which would ideally render emergency room visits unnecessary.

4.1. Community Care Application Model

The first step in our development process that uses the CPMA meta-model is to identify the key states or checkpoints in the palliative care process where forms are required to mark key transitions of patients from one state to another which are relevant to performance monitoring. The metrics that measure community care goals will be linked to the states and/or forms from the palliative care processes where data will be collected. Figure 3 depicts the palliative care process state model that was used for PAL-IS2. Each transition corresponds to a form. The process begins with a *Referral* form from a physician or facility requesting palliative care services. An *Appointment* form schedules the next regularly scheduled consult. However, if the patient is distressed, there may be an alert raised (recorded in an *Alert* form) and the patient will have an unscheduled consults. Scheduled and/or unscheduled consults continue until there is either a *Decease* form or a *Discharge* form (i.e. if patient goes into remission and is no longer considered terminally ill). This application model worked well for PAL-IS2, which was used to monitor the care process delivered by a single team of palliative care specialists, and it was straight-forward to track the key metrics associated with the various wait states in the process. There were, however, challenges that arose in attempting to apply it to PAL-IS3 which monitored care across a wide variety of care providers in the region.

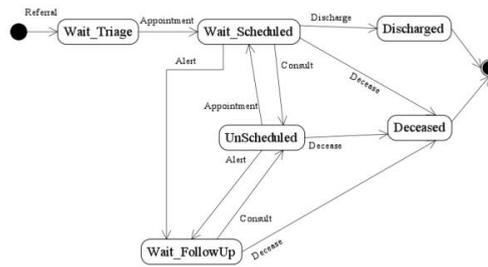


Fig.3 – Palliative Care Process State Model

4.1.1. Limitations and adaptations in using the application meta-model

First, focusing on the care process model, PAL-IS3 has an added level of the complexity because there are multiple facilities and different types of facilities participating in the delivery of services, each of which may have different care processes, or which may have variations on common care processes. Therefore it was not possible, with the current state of community palliative care, to define a single care process. Further, there was no element in the meta-model from Figure 1 to represent the different facilities.

Second, focusing on the enterprise model, there was a very large number and type of information technology systems in the community that could provide data in the form of events, but there was no consistency in what data was collected from facility to facility, or in the format of the data. Worse, there were significant organizational barriers (related to data governance) to receiving the information electronically. It was decided for that reason that we would focus on developing a mobile forms app that would collect the data we needed. However, the meta-model from Figure 1 did not have a means for specifying what resource was responsible for collecting the data for a particular form/event.

Finally focusing on the performance model, PAL-IS3 had a much larger set and variety of complex metrics (22) than had previously been encountered with PAL-IS2. More importantly, there was a significant gap between the desired metrics and the data available in the community to measure them. It was not possible to work strictly top-down from goals to metrics to event data. We could not collect all 22 metrics at once but rather it was necessary to mediate between what data might be available or collectable and the desired goals to craft “compromise” metrics that would both be good enough to measure performance goals and be practical to collect.

As a result, we found ourselves developing a new type of iterative methodology for building the PAL-IS3 CPMA. Rather than building a comprehensive CPMA all at once, our alternate approach was to select from the 22 metrics an absolute minimum set of meaningful metrics for which data collection is feasible across a useful subset of the region, to give an initial CPMA as a base line monitoring tool. The key strategy is to identify where in the community (what facilities) the data can be collected; and identify who in the community (what resource) is the best mechanism for collecting such data.

Table 1. Application Model for Community Care.

Goal	Metric	Forms	Facility	Resource
Access	% of Patients referred for Palliative Care by facility	Referral	CCAC	CCAC Nurse
Education	# Providers receive LEAP training by facility	Training	Training facility	Training Admin
Care	# Patients in ED < 2weeks before death by facility	Referral	CCAC	CCAC Nurse

Table 1 depicts the set of metrics we used to build a small but coherent application model that is “good enough” to provide an initial view of performance. There are no states or rules in the model, but for each form/event we identified the resource (and facility) responsible for collection. The source for all forms is the QuickForms server. For the Access goal, we focused on identification of palliative care patients across the community. Community Care Access Centres (CCAC) are the facilities in the community that coordinate approximately 80% of Community Care Palliative Nurse visits. We track patients referred to that service by other facilities on a yearly basis. For the Education goal, we decide to track providers that have completed LEAP training on a yearly basis, by facility. The administrator at each training facility is the resource in the community responsible to collect training data each time a course is offered. For the Care goal, reducing the number of palliative care patients who visit the Emergency Room (ER) during the last two weeks of life is a priority goal to measure. A palliative care patient can be stabilized at home with regular visits from a home care nurse, which should eliminate the need to unexpectedly visit the ER. The CCAC palliative care nurse assigned to a patient’s case is the resource in the community to collect data about avoidable patient visits to the ER (i.e. unmanageable pain in the middle of the night).

4.2. Standards and Indicators Committee Report

A trend report by facility will provide the Standards and Indicators Committee as well as individual facilities involved in community care with visibility into the palliative care strategy for improving delivery of care. Figure 4 shows an example report that illustrates how to measure the impact that the LEAP education initiative might have on the total number of referrals and number of ER visits. This report shows that as LEAP training is rolled out in the community, the percentage of providers at the facility that receive LEAP training is increasing from year to year. This should increase the identification of palliative care patients in the community, which should lead to the increase in referrals for palliative care that is shown. This should also result in fewer total visits to the ER during the last two weeks of life (as shown for 2014) as more patients receive home care from a CCAC nurse.

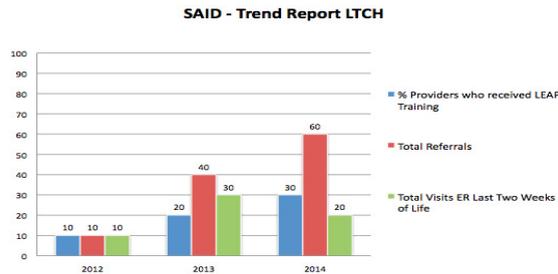


Fig. 4 Standards and Indicators Dashboard (SAID) - Trend Report

5. Evaluation

Our goal in this paper was to evaluate an existing meta-model for care process monitoring to see how well it can be applied to the community care case study described in section 4. In sections 3 and 4 we identified several differences between hospital and community based meta-models including data, process, resource, IT and methodological differences. Section 4 presented a case study that highlighted those differences and provided specific examples of the differences between hospital and community based process monitoring. Drawing upon the findings from the case study we formalized our findings into a table that compares hospital and community care process monitoring across four aspects: care process management, data management, resource management. Table 2 identifies several differences across the four aspects that will have significant implications on how we design performance monitoring systems for community care. With respect to process management, the biggest issue is that the processes that need monitoring are often vaguely defined and may not have explicit ownership. While the Standards and Indicators committee identified 22 metrics that it wanted to collect, they did not identify specific processes from which the data would emerge. The lack of defined process has a ripple effect into the data

management aspects because the data that is needed for process monitoring may not exist, or may exist in varying data standards and formats (i.e. paper and electronic). Further, because there is no enterprise data model for community based monitoring, the governance around data sharing may not exist, which may put limitations on the extent data can be shared across different settings.

Table 2. Comparison between Meta-Model Aspects for Hospital and Community Care Process Monitoring.

Meta-Model Aspects.	Hospital	Community Care
Care Process Management		
Clinical Pathways	Well defined pathways often exist for clinical processes	Pathways are ill defined or non-existent
Events	Typically well defined (ie. therapies, transfers, discharges)	Not well defined, in a variety of ways. Tracked by paper forms.
Data Management		
Data Sources	Data based on standards available from an integrated enterprise data model	Data often unstructured and undefined, enterprise model rarely exists
Data governance	Enterprise data model has governance rules for access	Data governance to be defined and problematic across organizations
Metrics and analytics	Metrics are calculated from integrated enterprise data model	Metrics defined but who and where to collect data in the community is not
Data collection	Data sources, events and forms are well defined	Data source & forms not well defined and may exist in a variety of paper and electronic formats
Resources Management		
Resources governance	Well defined and able to associate providers with processes.	Not defined. Need to identify where resources are in the community
Systems Management		
System Objectives	Patient is defined by their state of illness. Objective is to get the patient through the health system in as efficient a manner as possible	Patient is defined by the state of their health. Objective is to keep the patient in the highest state of health to minimize use of system resources
System Design Methodology	Top-down, requirements are developed and implemented in large scale fashion	Emergent & bottom up, requirements are often initially vague or undefined and are developed through small-scale iterative implementations
Information System interoperability	Integrated systems, often with a common enterprise data model	Disparate systems across multiple settings with different data models and degrees of interoperability

The biggest difference between hospital and community based monitoring is the methodology in which the system is designed and implemented. In a hospital based setting the requirements are well known and therefore a large scale top down implementation can be used. Community based process monitoring requires a very different strategy. In an ideal setting we would build a dashboard and information system to monitor performance based on existing information systems used by different care providers across the community. However that approach will require an effort of approximately 2-3 years to be fully deployed and users will not be able to realize whether the system works or to assess the system's usability until that time. That approach is simply not feasible because of the undefined nature of the processes and data in the community, because the data sources and resources to collect the data may not exist, and finally because collecting data on all 22 metrics is a change management issue and we cannot just add that amount of data entry burden to people's work routines at one time. Rather small incremental changes need to be done to assess the impact of the changes we are trying to implement.

6. Conclusions

While meta-models exist to support hospital based process monitoring, these models are not readily applicable to community based monitoring because of a variety of issues including data, process, resource and technology issues. In this paper we used a palliative care case study to evaluate a CPMA meta-model in the context of community care delivery. Our research identified several specific differences between hospital and community meta-models. These differences can be summarized into methodology and architectural issues. Unlike classic system design where a top down methodology is used, the opaque nature of community based care delivery requires a much more emergent and bottom up approach to systems design. Small incremental requirements have to be introduced in order to identify data sources and resources for data collection. Feedback can then be gained from the requirements from which an expanded set can be introduced. This iterative methodology continues until a complete set of requirements are created. The architecture (technology and environment) is also different in the community. Homes and community care centres are very rarely automated and connected. While technology is the driver in clinical care, the requisite technology (i.e. data feeds or data sources) often does not exist in the community. Therefore our approach was to start with a mobile forms application and identify the key resources required to obtain the needed data. The next step is to implement the CPMA in order to start collecting the data to support a performance monitoring dashboard for the Regional Standards and Indicators Specialty Committee. We will also be developing a revised version of our CPMA meta-model that can address both hospital and community-based CPMA's in a comprehensive and systematic fashion.

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