

Towards a Formal Process-driven Framework for Streamlining Patient-centric Care

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Abstract. Rapidly growing patient interest in enhanced engagement in care processes has motivated health organizations to provide patient-centric care delivery both in clinical and homecare settings. With the goal of giving each patient a more proactive role in their care, we motivate and propose a formal process-driven framework for streamlining patient-centric care and improving patient-provider communication. It will lead to patients having better access to health services and taking more responsibility in their health management. At the same time the burden on healthcare professionals is reduced, while enabling greater efficiency, improved safety and higher quality.

Keywords: patient-centric care, process-driven, clinical pathway, medical guideline, healthcare, patient-provider communication

1 Introduction and Motivation

Despite advances in life expectancy and quality of life, the current healthcare delivery system faces significant challenges in terms of cost, accessibility and quality. One of the goals established by the Institute of Medicine in 2001 is that healthcare delivery should be *patient-centric* [1], which means it should provide care that is respectful of and responsive to individual patient *preferences, needs* and *values*. As mobile devices become pervasive, and access to health information becomes easier, patients are becoming more informed. So, it is reasonable to assume that they will play a more interactive role in decision making about their health matters. Hence, there is a need to develop a formal methodology to foster patient-centric care service delivery.

Fig. 1 shows a clinical workflow that delineates the path of a patient who interacts with healthcare teams such as clinics, labs, and pharmacies. In this care process, the patient is the *only* constant who is involved in all the steps and communications among the large number of participants in the healthcare ecosystem. For example, when a patient schedules an appointment, or is discharged from a hospital, the patient communicates with *administrative staff*. At other points of care the patient undergoes clinical activities such as *detection* and *treatment*, which involves various entities

such as *departments, staff, resources*, etc. In this setting, it is important to consider a *process-oriented perspective* that *coordinates and maintains the flow of information between the patient and other entities to ensure an optimal outcome*.

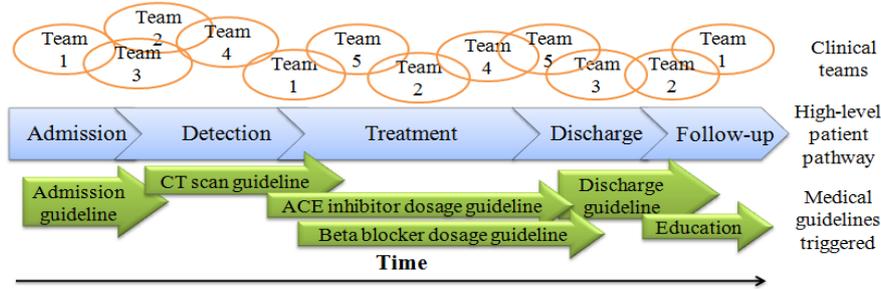


Fig. 1. The healthcare ecosystem

Recent years have seen an increasing interest in IT-based systems that support care delivery. *Although many process-driven approaches have been proposed to support clinical workflow, most are from the care providers' point of view.* Computer-Interpretable Guidelines (CIGs) formalize medical guidelines that were originally in the form of free-format text as computer executable languages, such as Asbru, EON, GLIF, PROforma, and SAGE [2]. The focus of CIGs is on supporting decision making based on best practice to improve the compliance of clinical practice and reduce variations. Thus, these methods are primarily designed for clinicians. Another stream of research uses workflow management systems (WFMSs) to automate and monitor patient pathways, with a focus on addressing specific healthcare challenges. For example, ADEPT_{flex} [3] offers greater workflow flexibility to handle exceptional events; Proclerts [4] succeeds in handling weakly-connected interacting workflows with different levels of granularity; Careflow [5] achieves an efficient implementation of clinical practice guidelines; etc. These WFMS systems address the logistics of patient flow from an organizational perspective, but hardly consider patient preferences.

More recently, as the focus of care providers shifts towards patient-centric care, a first step has been to develop applications that support patient access to their own health data and facilitate patient communication with providers (e.g., schedule appointments). A selection of web-based personal health record (PHR) systems, such as WebMD, is reviewed in [6]. Other efforts are devoted towards patient participation and decision making. For example, Porter et al. [7] designed an asthma kiosk application that captures critical information to drive guideline-based care for pediatric asthma. These patient-oriented systems have greatly improved patient communication with providers and their accessibility to health data. However, for the most part they fail to recognize the underlying process a patient undergoes in receiving medical care. We only found a few studies (e.g., Alberta's system [8]) that plan patient pathways for patient self-management. Hence, there is a need to *integrate the process perspective into patient-centric care and make it visible to patients, to facilitate patient-provider interaction in a structured manner and to give patients a more proactive role.*

This paper proposes a *process-driven approach* to streamline patient-centric care. We formalize clinical pathways based on guidelines and propose a patient information

model that incorporates patient needs and preferences. Thus, this framework aims to allow patients to: (1) access their health data and gain insights into the whole process; (2) express choices and take more responsibility; and (3) get a more personalized and coordinated continuum of care. Our approach also benefits the providers since it transfers patient communication workload from medical staff to the system, and tracks patient flows so that process improvement can occur. This paper is organized as follows. In Section 2, we propose a formal framework and describe the patient information model, followed by the decision making process in Section 3. Finally, we discuss future work and conclude the paper in Section 4.

2 A Process-driven Framework for Patient-centric Care

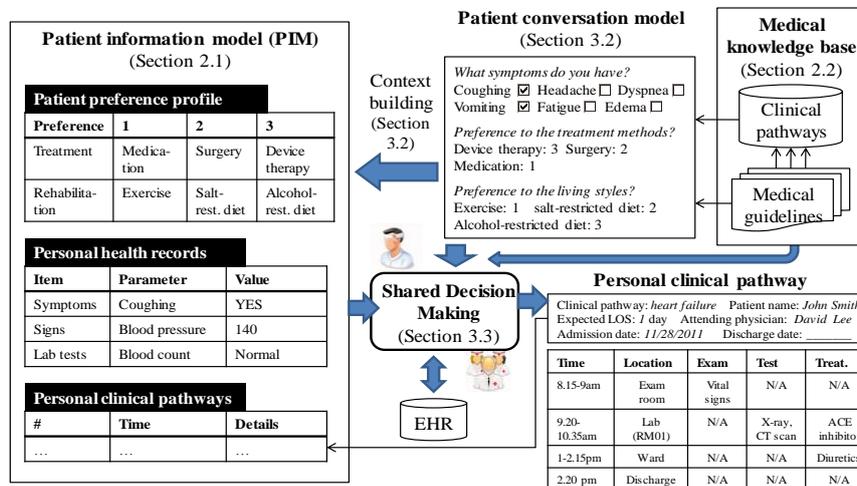


Fig. 2. Overview of process-driven framework for patient-centric care

Fig. 2 presents an overall framework for *process-driven, patient-centric* care delivery. All steps and decisions are driven by medical guidelines, patient preferences, and needs and values as captured in the *Patient Information Model (PIM)*. *Context-building* is the process of obtaining patient information by conversing with patients in a structured way, e.g., when they are at home or waiting in a clinic. Then, the framework integrates guidelines, aggregate information from past executions stored in the clinical pathways repository, patient needs and preferences, and invokes *the shared decision making* module to suggest options to the patient. The patient can review the options to learn about the issues that pertain to the care process. Finally, the doctor reviews these options, and possibly others also under consideration, with the patient. An action is determined based on their discussion and agreement. All medical decisions, actions, and outcomes for each patient encounter are documented in a *personal clinical pathway* which is recorded in the PIM. The system detects deviations from medical guidelines and requests the doctor to enter reasons for any major deviations, which are logged. The depersonalized process logs collected by our system are analyzed to provide patients with insights about the care of other patients that have expe-

rienced similar situations. This framework helps to guide patient conversation by semi-structured process models and coordinates activities among various participants. It helps to reduce the work required by the patient to interact with the system (e.g., reduce duplicate data solicitation, suggests options for patient learning) and enables the patient's participation in various tasks by letting them know what to expect of the care providers and what actions to take at all points of care. We describe the components of Fig. 2 further in the following subsections and in Section 3.

2.1 Patient Information Model

A *patient information model* (PIM) is comprised of three parts: *personal health record* (PHR), *personal preference profile* (PPP), and *personal clinical pathway* (PCP). PHR concerns a patient's lifelong health information that she is allowed to access, coordinate, and share with other parties [6]. It can include patient-reported symptoms, lab results uploaded by patients, or even data from sensors. Usually, it is maintained by patients themselves and can include data from health organizations that they have visited. Here, we assume that PHR is electronic, and is accessible online at any time.

The PPP captures an individual's preferences pertaining to her current situation. We use the rank-ordering method which is a popular comparative scaling technique to evaluate users' preference or liking [9]. For example, the matrix in Fig. 3 shows the preference profiles for patients P1, P2 and P3. It uses a $1 - N$ scale, where $N = \text{number of choices in an item category}$, for rank ordering the alternative choices within the heart failure guidelines. A larger number indicates a higher rank preference for a choice (1 being least preferred). Thus, the system is aware of patients' preferences of treatment methods, quality-of-life aspects, etc. This profile is acquired or updated from context-building to be discussed further in Section 3.

The PCP documents the actual decisions, actions and outcome organized in chronological order pertaining to a specific episode of care. Deviations from best practice may be necessary to satisfy a patient's needs.

Item	Applied strategy		Treatment method		Rehabilitation program		
	Normal	Aggressive	Medication	Surgery	Exercise	Diet	Physio
P1	1	2	1	2	3	2	1
P2	2	1	2	1	3	1	1
P3	1	1	2	1	1	2	3

Fig. 3. Matrix of patient preference profiles (partial)

2.2 Medical Guidelines and Clinical Pathways

A *medical guideline* is a document that guides decisions and criteria regarding diagnosis, management and treatment in a specific medical discipline (e.g., heart disease). This is naturally aligned with the way they are developed, i.e., by medical staff with different expertise areas. A *clinical pathway* implements medical guidelines after they are *tailored to local and individual circumstances* [10]. In a clinical pathway, different tasks are defined for various roles, and optimized in a logical time sequence. Outcomes are tied to specific interventions, e.g., following a healthy eating pattern for a

week might reduce blood pressure. A clinical pathway is basically a template from which concrete patient treatment cases (i.e., process instances) are derived. Fig. 4 depicts an example pathway that associates two medical guidelines from the Agency for Healthcare Research and Quality (AHRQ) for heart failure management [11]. In this way, Fig. 4 guides the evaluation and treatment of patients with heart disease in a structured, *process-driven* manner.

A *personal clinical pathway* (PCP) documents the actual execution for a specific patient. It may correspond to a clinical pathway such as Fig. 4. It keeps track of medical decisions (e.g., prescribe ACE inhibitor which is a pharmaceutical drug used primarily for treating hypertension and congestive heart failure), actions (e.g., dosage for ACE inhibitor), and patient outcomes in chronological order for each patient situation. Each task is associated with its time of occurrence. As noted above, deviations are allowed since humans control the actual execution of the process. A final outcome, e.g., the patient is cured, or ultimately passes away, indicates the end of a PCP. The PCP is a result of clinical decision making which is discussed further in Section 3.

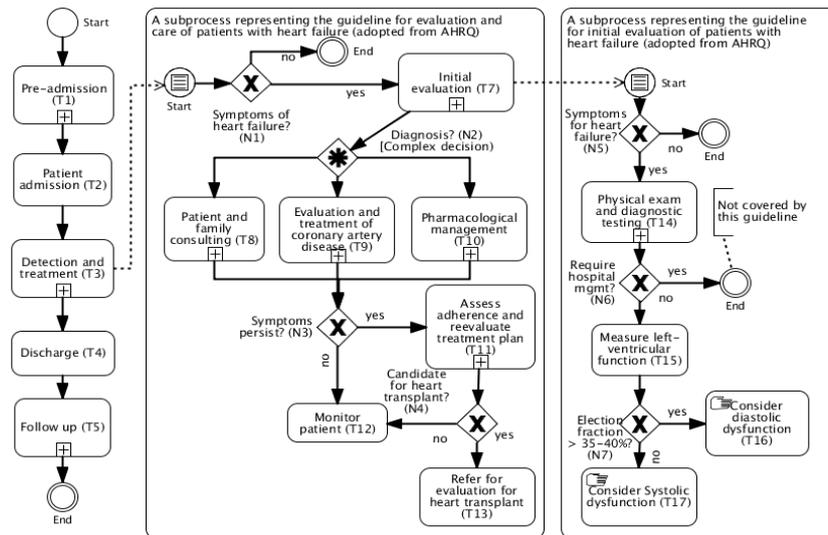


Fig. 4. A clinical pathway for two guidelines from AHRQ [11]

3 The Decision Making Process

In this section, we describe the shared decision making process. Medical knowledge for decision points is formulated as rules that are used to derive recommendations based on best practice and patient preferences.

3.1 Medical Rules

We use rules to embody medical knowledge. The rules help to make complex decisions in clinical pathways through logical reasoning. For example in the clinical pathway of Fig. 4, N2 is a decision node that decides the next step, e.g., treatment or

further evaluation, based on patient diagnosis results. A node can be associated with a number of medical rules. Integrating these rules and applying results from rule-based reasoning into a clinical pathway is critical for implementing evidence-based practice. In addition, each rule is associated with a *strength of evidence (SOE)* value to indicate its reliability. The three values for SOE are: A (good evidence), B (fair evidence), and C (expert opinion). They are based on a quality-rating system developed by AHRQ. For example, rule R1 is associated with task T10 and shows recommended medication based on “good evidence” (SOE equals A).

Rule R1 (Node: T10-medication): SOE=A
If a patient’s *systolic blood pressure < 90 mmHg* **and**
there is a *higher risk of complications*
Then prescribe *ACE inhibitors* managed by an *experienced* physician

3.2 Context-building through a Patient Conversation Model (PCM)

A medical decision is context-dependent, where context is patient specific. Our system can facilitate the process of learning about context by asking questions we expect of patients prior to their interaction with the care provider, and recording their responses. For example, in Fig. 4, context that is used at node T3 (detection and treatment) can be collected prior to that point, e.g., at node T1 (pre-admission) or T2 (patient admission). Then, depending on the patient answers, the subsequent questions need to be adjusted. We propose a *patient conversation model (PCM)* that describes the key questions asked at various points of care for a specific clinical pathway.

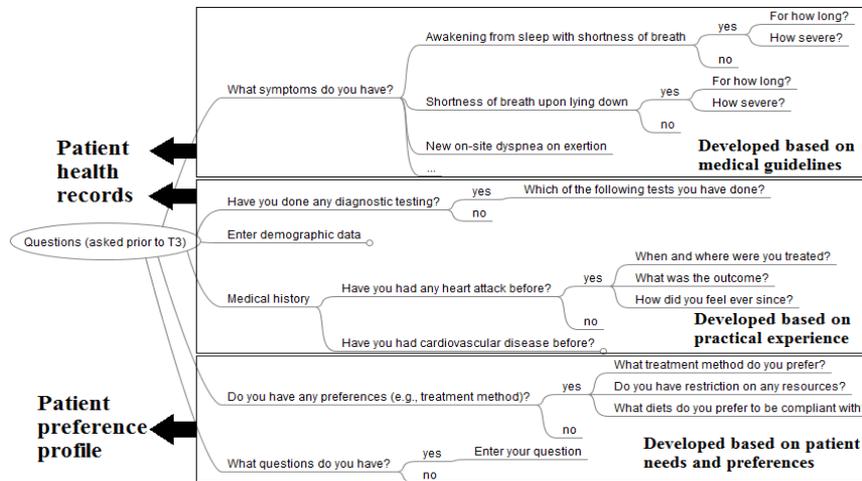


Fig. 5. A partial patient conversation model in a decision tree

Fig. 5 shows an example PCM for heart failure, represented as a decision tree. The top part is derived from medical guidelines and the other two parts are developed based on practical experience and patient needs. These questions are available for patients to answer any time prior to T3 in the clinical pathway of Fig. 4. For example, a patient can enter her answers at home or while waiting for examination. PCM is

process-aware since context becomes increasingly available as the care process proceeds. Via this model, we also give an opportunity to the patient to access information, e.g., the details of each treatment option (e.g., general success rate, relative cost, and side effects). Thus care providers spend less time on explanation.

3.3 Shared Decision Making

Medical decision making should follow best practice through medical rules and take into account patient information obtained during context-building. The decision algorithm works, briefly, like this: *when a decision node D is reached, we retrieve the rule set RS associated with D, run them against PHR and get evidence-based results.* Other options not triggered by rules may still be presented to patients who know that no guideline supports the options but that may better meet patient preferences. Fig. 6 shows an example of decision making at node N2 (Diagnosis). During initial evaluation, this patient underwent a physical exam and diagnostic testing. Her signs indicate that she might have had heart failure. Her systolic blood pressure is 85 mmHg, and there is a high risk of complications. As a result, medical rules (R1-R6) are triggered at different points of care and produce the results shown in Fig.6. ACE inhibitor (SOE = A) and Diuretics (SOE = C) are recommended based on best practice. Nevertheless, patients and doctors decide which option is chosen.

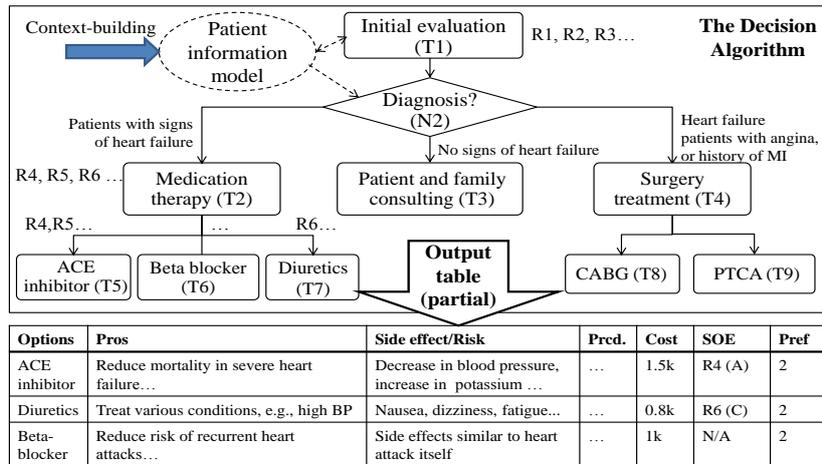


Fig. 6. Illustration of the process for recommending decisions

4 Discussion and Future Work

In general, care providers should promote consistency and uniformity in care delivery through implementation of evidence-based practice. The paradox is that, on the one hand, it is desirable to reduce variation by standardizing workflows to conform to best practice; on the other, clinical pathways should be designed to allow flexibility to meet specific needs of patients and resource constraints of a health system. Thus, a formal and radically new approach is required for streamlined communication be-

tween patients and providers to deliver evidence-based, yet personalized, care where patients can play a more proactive role in their health care matters.

In this paper, we describe the blueprint for such an approach. We propose a formal process-driven framework to streamline the communication between patients and care providers. Specifically, we introduce a patient conversation model (PCM) that informs the patient and the care provider, and a patient preference profile that informs the care provider. Introducing this information within care processes in a systematic way contributes to patient-centric delivery of care. This approach can benefit patients by allowing them to express their preferences and needs, and play a more active role in their own care. It also transfers a lot of the workload of handling patient communication from the medical staff to the system.

In future, we plan to extend and refine the structure of PCM models based on inputs from health professionals and patients. We also intend to automate the construction of the conversation model. Further, we expect to develop a patient portal based on existing open source tools as an engagement platform for patients and use HL7 messaging protocol [12] to interact with other health organizations to address the data interoperability issues. A prototype system is anticipated and further details of a cloud-based infrastructure to support this model will be described subsequently.

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