Journal of Biomedical Informatics 61 (2016) 298–318

Contents lists available at ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

An ontological model of the practice transformation process

Arun Sen [a,*], Atish P. Sinha [b]

[a] Department of Information and Operations Management – Mays Business School, Texas A&M University and Texas A&M Regional Extension Center in RCHI-Texas A&M Health Sciences Center, College Station, TX 77843, USA
[b] Lubar School of Business, University of Wisconsin-Milwaukee, Milwaukee, WI 53201-0742, USA

ARTICLE INFO

Article history:
Received 26 September 2015
Revised 6 May 2016
Accepted 7 May 2016
Available online 10 May 2016

Keywords:
Ontology
Patient-centered medical home
Key process area
Process modeling
Standardization

ABSTRACT

Patient-centered medical home is defined as an approach for providing comprehensive primary care that facilitates partnerships between individual patients and their personal providers. The current state of the practice transformation process is ad hoc and no methodological basis exists for transforming a practice into a patient-centered medical home. Practices and hospitals somehow accomplish the transformation and send the transformation information to a certification agency, such as the National Committee for Quality Assurance, completely ignoring the development and maintenance of the processes that keep the medical home concept alive. Many recent studies point out that such a transformation is hard as it requires an ambitious whole-practice reengineering and redesign. As a result, the practices suffer change fatigue in getting the transformation done. In this paper, we focus on the complexities of the practice transformation process and present a robust ontological model for practice transformation. The objective of the model is to create an understanding of the practice transformation process in terms of key process areas and their activities. We describe how our ontology captures the knowledge of the practice transformation process, elicited from domain experts, and also discuss how, in the future, that knowledge could be diffused across stakeholders in a healthcare organization. Our research is the *first effort* in practice transformation process modeling. To build an ontological model for practice transformation, we adopt the *Methontology* approach. Based on the literature, we first identify the *key process areas* essential for a practice transformation process to achieve certification status. Next, we develop the practice transformation ontology by creating key activities and precedence relationships among the key process areas using process maturity concepts. At each step, we employ a panel of domain experts to verify the intermediate representations of the ontology. Finally, we implement a prototype of the practice transformation ontology using Protégé.

1. Introduction

The US primary care system is struggling. Increasing demands and expectations, coupled with diminishing economic margins, have created a challenging work environment [1]. A key to the sustainability of primary care has been attributed to an approach called the "patient-centered medical home" (PCMH). PCMH is defined as a method for providing a comprehensive primary care which facilitates partnerships between individual patients and their personal providers, and when appropriate, the patient's family [2]. The key characteristics of PCMH are to foster the ongoing relationship with a personal physician, to promote physician-directed medical practice, to develop whole person orientation, to create care coordination, to assure quality and safety, to provide enhanced access to care, to support team care, and to support value-added payment. For example, a provider may know all of his/her patients by first name, but without a backup system, the provider's interactions with the patients cannot be documented and shared with the rest of the care team. Similarly, if an answering service cannot document all of its interactions with patients and provide evidence of the responses provided to patient queries, then no follow-up is possible. Without the crucial element of a formal call-back system in place, the coordination of care will suffer. This challenge is especially acute in the case of patients with complex chronic diseases. The provider cannot assure its patients of optimal care, no matter how personal and high-quality the interactions between patients and providers may be [3]. As the PCMH approach is quite different from the traditional model of practice, changes are needed in a practice to transform from the traditional delivery model to the PCMH model [4]. These changes constitute the practice transformation process (PTP) (see Table 1).

* Corresponding author.
E-mail addresses: asen@mays.tamu.edu (A. Sen), sinha@uwm.edu (A.P. Sinha).

http://dx.doi.org/10.1016/j.jbi.2016.05.001
1532-0464/

Table 1
Introducing practice transformation process [4].

Traditional Model of Practice	Practice Transformation Process (Converting Traditional Model to PCMH Model)	PCMH Model of Practice
Systems often disrupt the patient-physician relationship		Systems support continuous healing relationships
Care is provided to both sexes and all ages; includes all stages of the individual and family life cycles in continuous, healing relationships		Care is provided to both sexes and all ages; includes all stages of the individual and family life cycles in continuous, healing relationships
Physician is center stage		Patient is center stage
Unnecessary barriers to access by patients		Open access by patients
Care is mostly reactive		Care is both responsive and prospective
Care is often fragmented		Care is integrated
Paper medical record		Electronic health record
Unpredictable package of services is offered		Commitment to providing directly and/or coordinating a defined basket of services
Individual patient oriented		Individual and community oriented
Communication with practice is synchronous (in person or by telephone)		Communication with the practice is both synchronous and asynchronous (e-mail, Web portal, voice mail)
Quality and safety of care are assumed		Processes are in place for ongoing measurement and improvement of quality and safety
Physician is the main source of care		Multidisciplinary team is the source of care
Individual patient-physician visits		Individual and group visits involving several patients and members of the health care team
Consumes knowledge		Generate new knowledge through practice-based research
Haphazard chronic disease management		Purposeful, organized chronic disease management
Experience based		Evidence based
Struggles financially, undercapitalized		Positive financial margin, adequately capitalized

The current state of PTP is somewhat *ad hoc* and *no methodological basis exists* for transforming a practice into a patient-centered medical home. There exist several PCMH certification agencies, such as NCQA, BCBS of Michigan Physician Group Incentive Program, The Accreditation Association for Ambulatory Health Care, The Joint Commission to certify (http://www.jointcommission.org/assets/1/18/Joint_Commission_PCMH_model.pdf), etc. As the NCQA's certification program is the largest [5], we use this program as the basis for our research.

Practices and hospitals somehow achieve a certification level and send their information to a PCMH certification agency like the National Committee for Quality Assurance (NCQA) and BCBS of Michigan for practice certification [5], or wait for the Joint Commission visit to certify the hospital, completely ignoring the development and maintenance of the processes that keep the PCMH concept alive. Recent studies [6–8] point out that the change is hard, as it requires an ambitious whole-practice reengineering and redesign. Such a practice transformation includes new scheduling and access arrangement, new coordination planning, group visits, new ways to improve quality care, development of team-based care, multiple uses of information systems and technology, and other activities.

In this paper, we focus on the complexities of PTP and observe that one way to address the problem would be to create a *scientific* and *robust ontological model* that standardizes the practice transformation process. Ontologies have been used extensively in medical applications, such as developing clinical pathway guidelines, care pathways, and clinical decision support. Our goal is to develop an ontology that helps standardize the practice transformation process. Such an ontology will include a multitude of key process areas that are needed to transform the practice, as well as the precedence relationships among them. These can then be used by the practice to understand what steps are needed for transformation, so that it can attain NCQA's certifications.

The International Standards Organization (ISO) defines a standard as "a document that provides requirements, specifications, and guidelines that can be used consistently to ensure that materials, products, processes and services are fit for their purpose" (http://www.iso.org/iso/home/standards.htm). The standardization process includes two phases: *generation* and *diffusion* [9]. During the generation phase, standardization is launched, with different sponsors coming together to sketch the goals and purpose of the initiative. During the diffusion phase, the standardization results are distributed among the affected individuals.

An ontology helps share common understanding of the structure of information, enables reuse of domain knowledge, makes explicit domain assumptions, and analyzes domain knowledge [10]. These are the major motivations behind developing the ontology for practice transformation. If the ontology can accurately capture the PTP standards elicited from expert panels, we believe that it would provide an effective platform for diffusing the standards across key stakeholders in a healthcare organization, so that it can ascend to higher levels of process maturity and PCMH recognition. The ontology would facilitate the diffusion of PCMH standards by making it easier for end users to: understand the domain concepts, their meanings, attributes, instances, etc.; browse the concepts classification taxonomy; search for specific PTP KPAs and their activities; become aware of the domain rules and constraints; and reuse and apply the underlying knowledge base so as to conform to the PTP standards.

We have employed a concept called "process maturity level," which is quite well known in the process maturity literature The process maturity concept suggests that a process can become mature by progressing from some initial level (a state) to a more advanced level (a state). The notion of evolution utilizes stages of growth, suggesting that the process transitions through a number of intermediate states on the way to higher maturity states. In our practice transformation domain, practices also evolve through such stages of growth. Using the concept of practice transformation maturity levels, we have developed a grid that relates NCQA's certification levels with transformation process maturity levels. Such a grid provides a visual map for the practices to utilize the ontology for their transformation.