



# Evaluating practice-centered awareness in cross-boundary telehealth decision support systems



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## ABSTRACT

Building systems to enable knowledge sharing and decision support among clinicians across organizational and geographical boundaries is a complex but important task that lies at the core of the idea of telehealth. Practice-centered awareness has the potential to enhance the usability of cross-boundary clinical decision support systems by providing a shared context of work for decision support across organizational and geographical boundaries based on awareness of a clinician's work contexts and practice-related work activities, including local workarounds, non-explicit rules, improvisation strategies, institutional agenda and patients' needs. We present a multi-method evaluation of the practice-centered awareness features of CaDHealth. CaDHealth is a clinical decision support system that enables clinicians to construct awareness of one another's work activities and contexts across geographical and organizational boundaries based on three categories of work practice – ontological, stereotyped and situated work practices. Evaluation results indicate that incorporating practice-centered awareness features in telehealth systems results in better work coordination across organizational and geographical boundaries, leads to more effective cross-boundary clinical decision support, and enhances the perceived usefulness and adoption of telehealth and e-health applications.

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## 1. Introduction

Clinical decision support systems are widely used to improve quality of care and patient outcomes. In co-located health-care settings, their use often transpires in the midst of problem-based “conversational encounters” (Vyas, 2011, p. 1) between clinicians about a clinical case at hand; joint critical appraisal of research evidence, a guideline or patient's medical record; referrals to a secondary care specialist; and team-based formulation of a care plan or workflow (Abidi, 2006). Decision support in such contexts typically happens interactively and extemporaneously (Whittaker et al., 1994; Bardram et al., 2006; Mejia et al., 2010), and is largely driven by a common ground (Kuziemsky and Varpio, 2010) offered by the clinicians' shared context of work (Kirsh, 2001) and “knowledge-in-practice-in-context” (Gabbay and le May, 2011, p. 64). As the use of information and communication technologies to support healthcare at a distance, particularly in tele-expertise (Doubouya et al., 2014), envisions a distributed healthcare environment (Institute of Medicine, 2001; Silber, 2004) in which practitioners share knowledge across geographical and workplace boundaries in a way that adapts to patients' needs and clinical work contexts, it becomes necessary to ascertain whether the same efficiency and seamlessness that have sustained the culture

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of knowledge sharing and decision support in co-located healthcare environments can be leveraged to enable cross-boundary clinical decision support in e-health.

Advances in telehealth and e-health (Della, 2001; Iakovidis et al., 2004), for example, seeks to address the challenge of developing environments to support knowledge exchange among clinical professionals across geographical and regional health information networks (Silber, 2004; Tsiknakis et al., 2005; Tan, 2005; IANIS, 2007). In its groundbreaking report, (Institute of Medicine, 2001) acknowledges the need for an interconnected healthcare system that is patient-centered and takes cognisance of local practices, while maintaining a shared purpose and standard of care. Responsiveness to both patients' needs and local practices (Institute of Medicine, 2000; Stewart, 2001; Tsiknakis et al., 2005) thus constitutes an essential ingredient to achieving the goal of a successful e-health infrastructure, where the subsystems follow "simple rules adapted to local circumstances" (Tsiknakis et al., 2005, p. 300). As healthcare delivery unfolds within a diversity of contexts and actors, realizing the degree of adaptive cross-boundary decision support required in e-health calls for approaches that seek to address the human and organizational factors that are evidently a part of the context of healthcare service delivery, and provokes a number of research challenges. For example, how to define the context of clinical work in terms of human and organizational factors; and how to bridge the gap between two contexts of clinical work in order to enable adaptive cross-boundary decision support among clinical practitioners. In e-health and telehealth<sup>1</sup> (Silber, 2004; Eysenbach, 2001; Anya et al., 2011), the awareness of who is doing what, what resources are available for care delivery, what constitutes the context of work (Kirsh, 2001), and what patients' needs are, across geographically-bounded work environments and communities, becomes particularly important (Anya et al., 2010; Dobre, 2011). Practice-centered awareness encompasses a means to enable cross-boundary clinical decision support by adapting information across geographical and workplace boundaries to suit a user's local work context and practices. Work practices serve not only as the context to knowledge, but also as the anchoring point for the enactment of collective learning and knowledge sharing across communities of clinical practice (Wenger, 1998; Samiotis and Poulymenakou, 2002).

This paper discusses the evaluation of the concept of *Practice-Centered Awareness (PCA)* in the context of a cross-boundary clinical decision support system – CaDHealth (Anya, 2012). A key focus of CaDHealth is to enable decision support among clinicians in different geographies at the work practice level – the level at which work actually gets done in the real world, including how clinicians develop and use clinical knowledge in practice. CaDHealth contributes the notion of PCA to the design of telehealth and e-health applications. It *enables clinicians across geographical and organizational boundaries to share knowledge to support one another's decisions in a way that allows them to maintain awareness of each other's work situations and patients' needs at the work practice level*. In what follows, we discuss related work, and present an overview of the design of CaDHealth. We then discuss an evaluation of CaDHealth with a focus on the system's practice-centered features. Finally, we present a discussion of the evaluation results.

## 2. Related work

One of the main challenges facing evaluation methods designed to measure awareness is the inherent difficulty in operationalizing and measuring the constructs, such as workspace, activity, concept, group structure, sociality, informality, conversation, practice, etc. upon which the design of awareness is variously based. These constructs are a core part of our natural ability as humans, but become tremendously difficult to quantify when they are made an attribute of a software system. For example, we easily allow our understanding of the reasons for carrying out a task, as well as the specific purpose and requirements for pursuing the task to bear on our performance of the task – *task awareness* (Prinz, 1999). We maintain an awareness of the artifacts and environments for executing the task, for example, whether the task folds on the field, in an office or in a laboratory – *workspace or workplace awareness* (Gutwin, 1997; Bardram and Hansen, 2010). We are even able to keep track of what is happening by the wayside as we perform the task – *peripheral awareness* (Matthews and Mankoff, 2005), or maintain awareness of an association of people to whom the task matters or the organization for which the task is being performed – *organizational awareness* (Ackerman and Halverson, 2000). An awareness of the state of knowledge that one needs to maintain to work in a complex environment or operate a dynamic system – *situation awareness* – is another example that has been explored in the human factors community (Endsley and Garland, 2000).

Usability evaluation method, in particular heuristic evaluation, remains the most widely used method for evaluating awareness. Heuristic evaluation was developed for evaluating single user applications, and relies on the subjective opinion of an expert. During the process, experts work individually to identify usability issues in a design, a prototype or a live system by applying a set of heuristics or rules of thumbs. Nielsen (1994) developed the most widely used set of heuristics for system evaluation. A key contribution of the work we describe in this paper was to integrate heuristic evaluation with one of Endsley's (1995) well-known situation awareness evaluation techniques, namely the Situation Awareness Global Assessment Technique (SAGAT), as well as controlled experimental methods (Cairns and Cox, 2008).

A number of related work on workspace evaluation (e.g. Gutwin, 1997) have relied on heuristics with the aim of making sense of who, what, where, when, why, and how questions about what other users are doing in a collaborative work

<sup>1</sup> Different definitions of telehealth and e-health appear in the literature with subtle differences between their meanings and applications. However, in this paper we use both terms in a broad sense to denote the use of electronic communication and information technology in healthcare practice, in particular to support (long-distance) cross-boundary and cross-organisational clinical decision support among clinical practitioners.

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