Chapter 1
Clinical Workflow in the Health IT Era

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Health information technology (IT) in general, and electronic health records (EHR) in particular, hold great promise to cross the quality chasm of the healthcare system and to bend the curve of ever-rising costs (Institute of Medicine (U.S.) 2001; Girosi et al. 2005). However, health IT implementation projects globally have experienced a wide range of issues, from rollout delays to budget overruns (Kaplan and Harris-Salamone 2009). Successfully deployed systems often fail to generate anticipated results (Black et al. 2011; Kellermann and Jones 2013); some are even associated with unintended adverse consequences (Ash et al. 2007; Campbell et al. 2006; Koppel et al. 2005; Zheng et al. 2016).

In the U.S., for example, over $30 billion has been invested in accelerating EHR adoption and promoting its "meaningful use" through the appropriation from the Health Information Technology for Economic and Clinical Health (HITECH) Act 2009 (Blumenthal 2010; Blumenthal and Tavenner 2010). While the program has

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been largely successful in boosting EHR penetration rates across U.S. hospitals and clinics (The Office of the National Coordinator for Health Information Technology (ONC); Office of the Secretary, United States Department of Health and Human Services (HHS) 2018), research on the effectiveness of the systems implemented has showed mixed results (Jones et al. 2010; Romano and Stafford 2011). In their Health Affair article entitled "*What it will take to achieve the as-yet-unfulfilled promises of health information technology*," Kellermann and Jones concluded that despite the widespread adoption of health IT, the quality and efficiency of patient care in the U.S. were only marginally better; and the annual aggregate expenditures on healthcare continue to soar (Kellermann and Jones 2013).

Disruption to clinical workflow as a result of health IT implementation has been repeatedly shown as a major cause for the under-realized value of health IT. A key issue is that today's health IT systems are often designed to simply mimic existing paper-based forms, and thus provide little support for the cognitive tasks of clinicians or the workflow of the people who must actually use the system (National Research Council 2009). Similarly, in a systematic review of the health IT evaluation literature, Buntin and colleagues found that a considerable number of studies reported negative or mixed findings, and that "most negative findings within these articles relate to the work-flow implications of implementing health IT, such as order entry, staff interaction, and provider-to-patient communication" (Buntin et al. 2011: 467).

"More/New Work" and "Unfavorable Workflow Change" are two workflow disruptions that have been most often discussed in the literature; both are directly attributable to the radical changes to established clinical workflow associated with introduction of health IT (Ash et al. 2007; Campbell et al. 2006; National Research Council 2009; Niazkhani et al. 2009). While some changes are purposefully planned—to reengineer existing processes to take full advantage of new capabilities offered by health IT—some are manifestations of a wide range of problems such as poor software usability, misaligned end-user incentives, rushed implementation processes, and the lack of sociotechnical considerations to effectively integrate software systems into their complex behavioral, organizational, and societal contexts (Ash et al. 2007; Campbell et al. 2006; National Research Council 2009; Niazkhani et al. 2009).

It is therefore critical to develop a comprehensive understanding of the impact of health IT on clinical workflow, in addition to their root causes, mechanisms, and consequences. Unfortunately, studies of these phenomena are still relatively scarce, and available findings are often inconclusive or conflicting (Unertl et al. 2010; Zheng et al. 2010; Carayon and Karsh 2010). Further, a consensus on the research definition of "clinical workflow" remains elusive, especially in the context of assessing workflow changes introduced by health IT (Unertl et al. 2010).

While conceptual models are available, e.g., (Unertl et al. 2010) many challenges remain in the development and application of robust measures of changes to clinical workflow (Zheng et al. 2010). Methods used in existing workflow studies vary to a great extent (Unertl et al. 2010; Zheng et al. 2010; Carayon and Karsh 2010; Zheng et al. 2011; Lopetegui et al. 2014). Even among studies using the same method, a

considerable degree of discrepancies exists in application of the method and interpretation of study results (Zheng et al. 2011; Lopetegui et al. 2014). For example, time and motion is considered to be the "gold standard" approach for obtaining quantitative assessments of clinical workflow; yet among the time and motion studies published to date, there has been a large degree of methodological inconsistencies in the design, execution, and results reporting of those studies, such as how inter-observer reliability is assessed and how multitasking is handled (Zheng et al. 2011; Lopetegui et al. 2014). This issue has significant implications for the rigor and generalizability of time and motion studies, diminishing our ability to accumulate knowledge as a field. As commented by Carayon and Karsh in a comprehensive literature survey report commissioned by the U.S. Agency for Healthcare Research and Quality (AHRQ), the empirical evidence of health IT's impact on clinical workflow has been "anecdotal, insufficiently supported, or otherwise deficient in terms of scientific rigor" (Carayon and Karsh 2010: 7).

This book intends to address several of these knowledge gaps by bringing together a team of experienced researchers and practitioners who have dedicated their career to studying and improving clinical workflow. Several chapters included in this book are results of a series of research or quality improvement efforts spanning multiple decades; some are syntheses of the research literature since early 1900s, bringing together what we know about clinical workflow, where gaps remain, and how these gaps can be addressed in future research.

This book is organized into four Parts and 19 Chapters. Part I, *Clinical Workflow and Health Information Technologies*, orientates readers to the problem domain, basic concepts (e.g., cognitive behavior and workflow modeling), and consequences of disrupted workflow due to health IT implementation.

Part II, *the State of the Art of Workflow Research*, summarizes workflow studies conducted in healthcare in the past few decades. We purposefully include in this section workflow research from a non-healthcare domain, aviation, to draw a comparison between how clinical workflow differs from workflows in other industries and how they are conceptualized and studied differently. Part II also includes a chapter specifically on multitasking and interruptions, which are two defining characteristics of clinical workflow that have significant efficiency, care quality, and patient safety implications; in addition to chapters that address nursing and patient perspectives, and workflow-related issues during patient handoff and when patients transition from one healthcare setting to another, i.e., workflow at the edges.

Part III, *Research Methods for Studying Clinical Workflow*, introduces research methodologies that have been commonly used in clinical workflow studies, including work sampling, time and motion, human factors engineering, and emerging methods that leverage sensor technology for automated data collection and real-time workflow assessment. Part III also includes a chapter that discusses the unique characteristics of quantitative workflow data and consequently unique challenges to statistically analyzing such data.

Part IV, *Applications and Case Studies*, first presents one large clinical workflow study supported by the U.S. Agency for Healthcare Research and Quality (AHRQ) that looked into how health IT systems, introduced as part of ambulatory care prac-

tice redesign, impact clinical workflow. Part IV then presents three case studies each focusing on a distinct perspective. These include effort in reengineering clinical workflow to enable a cross-continental collaboration on creating continuously monitored intensive care units, and efforts in enhancing clinical pathways, clinical rounding, and patient handoff communications.

By compiling a collection of high-quality scholarly works that seeks to provide clarity, consistency, and reproducibility in workflow research, we hope to create a repository of knowledge to inform future studies on health IT design, implementation, and evaluation. In addition to a research reader, this book offers pragmatic insights for practitioners in assessing workflow changes in the context of health IT adoption, and in implementing remedial interventions when such strategies are warranted. The book is also designed to present the state of the art on clinical workflow research, providing an excellent reader for graduate students in all clinical disciplines as well as in biomedical and health informatics.

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