

Unintended Adverse Consequences of Health IT Implementation: Workflow Issues and Their Cascading Effects

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Abstract

The implementation of health information technology (HIT) in clinical settings can have adverse effects to workflow, such as new or increased work, interruptions and distractions, delays or inefficiencies, duplicated work practices, and changed or disrupted communication, which can have additional effects on both clinicians and patients and also lead to workarounds. Negative effects such as increased clinician cognitive load and risks to patient safety can be at least partially linked to these workflow problems. In this chapter, we summarize literature on unintended negative consequences in the context of workflow. Based on prior research, we categorize these effects as primary and secondary unintended negative consequences, and we provide a conceptualization for these workflow issues and their cascading effects. By considering workflow issues as primary consequences and beginning to unpack the complex relationship between these issues and their secondary impacts, we can better anticipate and address the adverse effects of HIT implementation.

Keywords: health information technology (HIT), workflow, unintended consequences, adverse effects, workarounds, healthcare, clinicians, patients

1. Introduction

Health information technology (HIT) has great promise as a means to improve patient quality and safety. However, the introduction of HIT can impact healthcare practices in unintended ways, leading to unintended consequences. The term “unintended consequences” refers to unforeseen or unpredicted results to a specific action [1] and is commonly used to discuss technological impact, especially related to healthcare. These consequences can be positive, negative, or neutral. However, much of the focus on unintended consequences is on negative effects. Therefore, we focus on unintended negative consequences of technology in healthcare settings.

Numerous research has been devoted to understanding the unintended consequences of HIT. While many papers have reviewed literature to understand the state of the art of unintended consequences [2–13], the purpose of this book chapter is to discuss the unintended consequences in the context of *workflow*. Workflow is an essential component of healthcare because it encompasses all the activities and processes around delivering patient care. According to the US Department of Health and Human Services [14], workflow can broadly be defined as “*the sequence of physical and mental tasks performed by various people within and between work environments. It can occur at several levels (one person, between people, across organizations) and can occur sequentially or simultaneously.*”

Understanding workflow in clinical settings is essential to designing and deploying usable HIT. “*A critically important component of an organization’s preparation for an HIT implementation is a thorough review of its workflow processes, procedures, and role assignments; yet the complexity of the healthcare workflow makes it resistant to many conventional workflow modeling and automation approaches*” p.88 [11]. Without paying close attention to workflow,

users may not accept the systems we implement, and the systems may cause unintended negative consequences, which may negatively impact patient care [15].

The term unintended consequences in the context of HIT became popularized in the early to mid 2000s by researchers like Joan Ash conducting research on the effects of patient care information systems [16] and computerized physician order entry [17]. However, thinking about the effects of HIT was not new (e.g., [18]). Therefore, numerous terms that may refer to unintended consequences exist in the literature. Because many focus on the negative aspects, unintended adverse consequences (UACs) is commonly used to refer to unintended negative consequences, such as more/new work for clinicians and disrupted/altered communication practices [1, 19, 20].

While many researchers use the term unintended consequences broadly [21–26], some researchers call these impacts [19, 25, 27], effects [27], residual consequences [21], or simply problems [22]. For example, Vishwanath et al. [27] did not explicitly discuss unintended consequences but talked in depth about the impact and effect of the electronic medical record (EMR) on outpatient workflows. Wu et al. [25], on the other hand, used the term unintended consequences, but they also referred to these issues as impacts. The variety of terminology suggest a broad interest in unintended consequences. However, this also means there are many more papers that discuss unintended consequences beyond what we include here.

This book chapter aims to summarize what we have learned about unintended negative consequences in terms of workflow in clinical settings. The structure of this chapter is as follows: First, because workflow is broad, we characterize the impact type in the context of workflow. This includes a discussion about workflow issues as primary unintended consequences as well as secondary unintended consequences that result from workflow issues. We also present a diagram that begins to unpack these complex workflow issues. Next, we talk about the causes of and proposed solutions for these workflow issues. Finally, we conclude with future directions.

2. Characterizing Unintended Consequences

Understanding and discussing HIT's impact on workflow can be a challenge because workflow encompasses all activities around patient care. The introduction of HIT is often associated with direct changes in workflows (such as increased work, delays, etc.) that have been widely noted in literature. We refer to these as primary unintended consequences. In addition, there are more invisible (or indirect) impacts that result from these primary consequences, which we refer to as secondary unintended consequences. Primary unintended consequences (in this case, workflow issues) lead to other issues that affect clinicians and ultimately patients. For example, disrupted and fragmented workflow can lead to an increase in medical errors resulting in patient safety issues [28–30]. Thus, we discuss workflow issues as primary unintended consequences as well as what we view as secondary consequences that may occur as a result of these workflow issues.

2.1 Workflow Issues as Primary Unintended Consequences

In many cases, unintended consequences of HIT implementation directly affect the work practices of clinical and non-clinical staff (e.g., medical billing and coders, receptionists, and IT staff). However, many studies tend to focus on clinical staff, and therefore, this chapter discusses workflow mainly in terms of clinical staff. Because these work practices are part of healthcare providers' workflow, we can view these workflow issues as unintended consequences themselves. These consequences include new or increased workload [1, 24]; delayed work or time inefficiencies [2, 19, 22, 31]; interruptions or distractions [19, 21, 25, 26]; duplicated work practices [1, 21, 22, 24]; and changed or disrupted communication [1, 25].

New or Increased work: HIT can create new work or increase the workload of healthcare providers and staff. For clinicians, for instance, computerized physician order entry (CPOE) systems require more work in order to get to the “patient overview” than before HIT implementation [1]. Healthcare providers’ workloads increase as they are forced to enter new information in the systems not previously required [1, 24] and respond to alerts that may not contain relevant or helpful information [1]. Entering patient information on these systems is new and added work, which takes away time from other tasks [24]. For nurses specifically, one of the most commonly occurring unintended consequences of EHRs is increased workload [24]. These new and added tasks alter the typical flow of work.

Work interruptions and distractions: As a result of the added or fragmented work, HIT may interrupt healthcare providers’ work processes or distract them from their work. These disruptions are caused from general HIT, like CPOE, EHR, and e-prescribing systems, as well as mobile devices adapted for clinical settings, such as iPods and smartphones. With the introduction of HIT, clinicians and staff must use technology to complete certain tasks, which changes their usual workflow. For instance, clinicians may spend more time and exert more energy to find a nearby computer workstation to enter patient information [19]. This added step not part of the workflow pre-HIT interferes with other aspects of delivering patient care. Sometimes the change in work processes also results in extra tasks that interrupts normal work. For example, in the case of pharmacy workflow, pharmacy staff may spend additional time restocking prescriptions that patients never picked up because they were auto-filled through the system [21]. While EHR systems as a whole are beneficial to society, these workflow disruptions are a major drawback [7]. While mobile devices improve access to information and response time [25, 26], they can also be a source of disruption. For instance, the “in the moment” communication afforded by smartphones causes frequent interruptions (e.g., imagine a clinician’s phone going off every few minutes) and large magnitude interruptions (e.g., direct phone calls) [25]. Similarly, iPods used in the operating room take away from collaborative work practices [26].

Work delays or inefficiencies: Along these same lines, sometimes the introduction of new HIT creates work delays and decreases time efficiency both internally and externally. For instance, Campbell et al. [1] reported CPOE systems slow the process of clinical documentation and ordering. Similarly, in the context of pharmacy workflow, Zadeh & Tremblay [2] conducted a literature review from 2008 to 2014 to understand the benefits and risks of e-prescribing systems and found 38% of studies included in their analysis related to reduced pharmacy workflow efficiency as the result of unintended consequences. Inefficiencies are not limited to inside one clinical space; in fact, external interactions among insurance companies, laboratories, hospitals, etc. also cause work delays [31]. While there are discrepancies between some qualitative and quantitative studies about the impact of HIT on workflow efficiency, these may be due to how flow of work is measured. For example, Zheng et al. [19] found CPOE systems cause a higher frequency of task switching and fragmented tasks, which may not be reflected by conducting a time utilization analysis.

Duplicated work practices: Another unintended consequence related to workflow is duplicated work practices. Sometimes HIT requires healthcare providers enter redundant information [24] or copy the same data from paper into the system [22]. In other cases, HIT causes duplicated results, such as with the case of medications. For example, Nanji et al. [21] found prescriptions were being dually transmitted – once through fax and once through the e-prescribing system -- often resulting in two of the same medications being filled for each patient. Similarly, Campbell et al. [1] found emergency orders were often duplicated because they were entered in

the CPOE system and then phoned in to ensure efficiency. These duplicated work practices are partly related to inefficient communication.

Changed or disrupted communication: Part of the typical flow of work is communication among healthcare providers and staff, which may be changed or disrupted as the result of HIT. CPOE systems may inhibit interpersonal communication because more and more information is conveyed via the system instead of through face-to-face conversations [1]. For instance, Wu et al. [25] found the use of communication tools, particularly smartphones, may cause a decrease in verbal communication that negatively impacts the relationships among clinicians. Instead of promoting real communication among healthcare providers and staff, HIT systems often provide only an illusion of communication whereby it is assumed the appropriate individuals will view and act on the information entered into the system [1].

2.2 Secondary Unintended Consequences Resulting from Workflow Issues

In addition to the unintended consequences to workflow, we discuss secondary unintended consequences often resulting from workflow issues. We begin this section by first discussing workarounds. Then we focus on the type of impact of secondary consequences -- describing in more detail those that affect the patient and those that impact the clinicians and staff.

2.2.1 Workarounds

Workarounds are actions people take to mitigate both primary and secondary unintended consequences. Sometimes workarounds are a direct result of the workflow issues [8]. For instance, to combat inefficiencies and to facilitate care coordination among internal and external entities, clinicians may write down patient information on paper [32] or take photos of electronic information on a nurse's workstation [33]. In other cases, while the root cause is workflow issues, the workaround is aimed at alleviating problems clinicians and staff face as a result of the workflow issues. For example, changes to work processes may increase the cognitive load of clinicians requiring them to use paper-based methods as a memory aid [32]. In section 2.2.2, we describe the secondary consequences that affect clinicians.

Many researchers study workarounds as part of understanding workflow [13, 20, 31, 32]. Workarounds are important to understand as they can signal unaddressed issues with HIT and may lead to additional unintended negative consequences, such as risks to patient safety [32] and delayed access or difficulties finding information [20]. According to Cresswell et al. [20], "workarounds arise from the strategies employed by individuals or groups of users of HIT to mitigate perceived barriers to completing tasks" p.548. These barriers often are the result of unintended consequences of HIT on workflow. While workarounds are often informal practices to mitigate these issues, they can also be formal organizational mandates to reduce risks to patient safety [20].

Workaround can be classified into different categories, such as individual, managerial, and artifact-based depending on who initiates the workaround and how it is enacted. Common workarounds include using paper and other software systems as intermediaries [20, 32] and staying logged into the system under another colleague's name [34]. For example, in the context of test result management, Menon et al. [32] found 70% of primary care clinicians who use workarounds report using paper-based methods and 22% report using a combination of paper and computer-based approaches. Paper-based strategies include printing paper, writing on sticky notes, creating paper lists and logs of electronic communication [32]. Computer-based strategies involve

transferring secure electronic information to calendar events, text files, and notes [32] as well as taking screenshots and photos of patient information [33].

2.2.2 Clinician-Related

Workflow issues that result from HIT adoption can impact clinicians in unintended and negative ways, including increasing their negative emotions [1, 35], increasing their cognitive load, changing institutional structure and power [1], and creating a reliance on technology [1]. As healthcare providers try to learn a new system and contest with changes to their work processes, they may experience guilt, annoyance, sadness, hostility, and disgust [35]. These unexpected and negative emotions often occur due to interruptions to clinical workflow and negative feedback from the system [35]. Not only are these negative feelings unpleasant for clinicians, but they also may make it more difficult for clinicians to complete complex physical and cognitive tasks [1, 35].

Changes and interruptions to normal workflow can also result in a higher frequency of task switching and multitasking among clinicians [19, 29]. This is disruptive to clinicians' work; however, it also is problematic because increased task switching and multitasking are associated with increased mental burden and cognitive load [29, 36, 37]. For example, unexpected interruptions, such as system alerts, system reminders, and phone calls lead to increased cognitive load and make clinicians more prone to error [29, 30].

By requiring added work and changing access to certain types of activities and tasks, HIT can impact individuals' roles and responsibilities, leading to changes to institutional power and structure [1]. For instance, CPOE systems redistribute work through role-based authorizations, which control who can what [1]. This shifts the structure and power within the organization and can create resentment among healthcare providers and staff [1].

As clinicians become accustomed to HIT, they develop a reliance on technology to do their work properly [1]. While adapting to the new, technology-dependent work processes is important, healthcare providers may become over-reliant on technology to deliver patient care, which becomes problematic when technology inevitably fails. In the event of a system failure, clinicians may be unable to recall relevant information (e.g., standard dosages and medication contradictions) that they relied on HIT to provide [1]. This can result in an increase in medical errors and/or delayed patient care [1].

2.2.3 Patient-Related

While arguably all aspects of healthcare impact the patient, there are some unintended consequences that are consistently discussed in the context of patient care, such as risks to patient safety [20, 24, 32] and threats to patient confidentiality and privacy. Workflow issues lead to a cascading effect on patient care. While workflow issues themselves can negatively impact patients, workarounds and secondary consequences that result in workarounds can negatively affect patients also. For example, disruptions to workflow and workarounds can increase the likelihood of errors leading to serious safety concerns [1, 12, 13, 20–22, 28, 32]. Because HIT is not always well-suited for the highly interruptive context of clinical workflow [28], it becomes easy for clinicians to select the wrong option or input an order for the wrong patient [28]. HIT requires complete and structured data, which can also cause cognitive overload that makes clinicians more susceptible to making mistakes [28–30]. In addition to workflow interruptions and cognitive limitations, workarounds also impact patient safety. While HIT was intended to reduce medical errors, workarounds sometimes facilitate rather than reduce errors [13]. Workarounds can delay

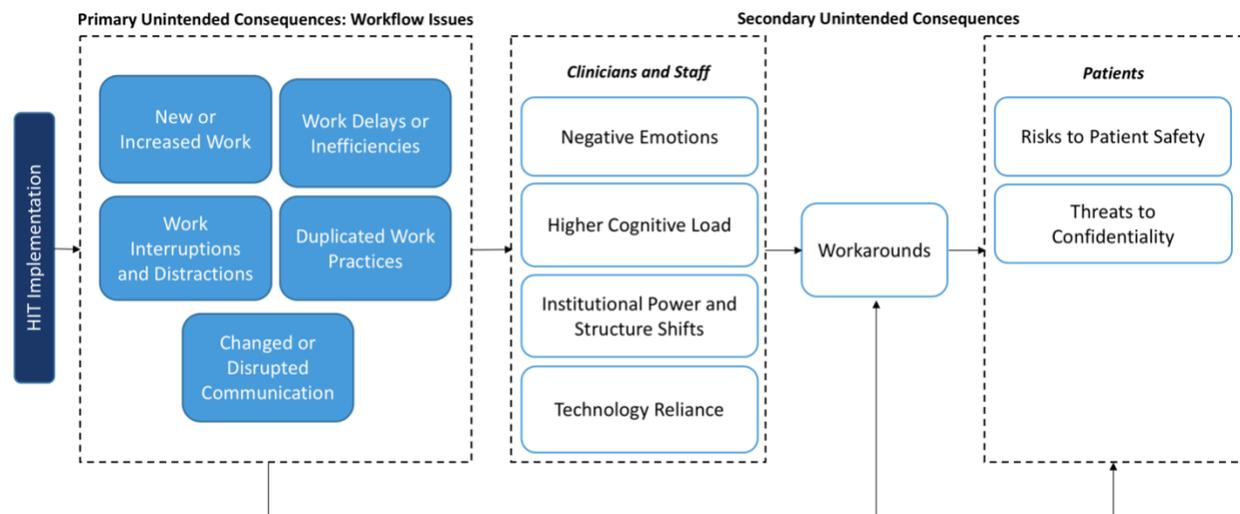
information and make it difficult for others to find pertinent information to make sound medical decisions about patient care [20].

Workflow issues can also impact patient confidentiality and privacy. Particularly, the use of workarounds, such as paper notes, screenshots, and photos, to improve efficiency and memory can threaten patient confidentiality by transferring sensitive patient information in an unsecure manner. For example, privacy may be compromised if a healthcare provider takes a photo on a personal phone of a patient's results and that provider then loses their phone. Although there are often privacy policies and security measures in place to prevent loss of confidentiality, clinicians may work around these security features and break privacy policies if the systems inhibit their work practices [33, 38, 39].

2.3 Conceptualizing Primary and Secondary Consequences of HIT Implementation

Although most unintended consequences are related to one another, we attempt to unpack them. Implementing technology can impact healthcare workflow, and these effects on the flow of work themselves can be viewed as primary unintended consequences of HIT. However, workflow issues can lead to other problems, such as an increase in clinicians' cognitive load and risks to patient safety, which are types of secondary unintended consequences. There is a relationship between these different unintended consequences, which is illustrated in Figure 1.

Figure 1. Primary and secondary unintended negative consequences of HIT



When HIT is implemented, it results in direct changes to workflow, such as new or increased work, work interruptions and distractions, work delays or inefficiencies, duplicated work practices, and changed or disrupted communication. These primary consequences can have secondary impacts on clinicians and patients and lead to workarounds. As the result of workflow issues, clinicians often face secondary consequences, such as negative emotions, higher cognitive load, institutional power and structure shifts, and technology reliance. When clinicians are overburdened or upset, they may resort to workarounds in an attempt to ease these secondary consequences. However, workarounds that directly result from workflow issues and workarounds that result from the secondary issues clinicians encounter can negatively impact patient safety and privacy. Thus, risks to patient safety and threats to patient confidentiality can also be viewed as secondary unintended negative consequences of HIT implementation. It is important to note that this figure is not meant

to be an exhaustive list of unintended negative consequences related to workflow or a comprehensive diagram showing all causal relationships but rather an overview to stimulate conversation and research around understanding and improving workflow issues to minimize both primary and secondary unintended negative consequences.

3. Causes and Solutions of Workflow Issues

Workflows issues result from a mismatch between systems and workflow practices [24] [1] [22], affordances of the technology [25] [26], and lack of standardization across external sites [32]. Most commonly, workflow issues occur when there is poor integration between actual work practices and HIT [24][1] [22]. HIT tends to rigidly model workflow according to organizational and governmental policies, which do not accurately reflect workflow in real-world clinical settings [1]. Nuanced, non-linear, complex, and sometimes invisible processes are not easily translated to system design. HIT also tends to neglect the range of workflow perspectives; that is the work practices around the same task look very different depending on an individual's role [1]. HIT changes work practices, and work practices and social systems around HIT impact how they are used [23].

Affordances of newly introduced technologies also result in workflow issues. However, some system limitations are intentional. This is the case with features like system timeouts and passwords [33, 38, 39], which are “limitations” designed to protect data security and patient privacy. In other cases, the HIT is simply not capable of meeting users' needs. In addition to these system limitations, sometimes the affordances of technology adapted for clinical settings make them prone to disrupt workflow. For instance, smartphones easily disrupt workflow because of their ability to allow healthcare professionals to contact others “in the moment” [25] as well as their other capabilities, such as access to the web, email, etc. Similarly, despite some benefits, iPods used in the operating room can be a distraction because they are by design fun and entertaining; they allow healthcare providers to do personal activities, which may interrupt their normal work processes [26].

Additionally, workflow problems stem from a lack of standardization across external sites [31]. While HIT at one site may be well-integrated with the work practices there, clinicians' and staff's work may be negatively impacted when they have to share information and communicate with sites that do not share a common system interface. This may mean sites have different types of HIT that do not communicate well (or at all) with each other or one site uses technology and the other uses paper. These interaction across external entities, such as hospitals, specialty clinics, laboratories, and insurance companies, can cause work delays when communication cannot be effectively accomplished using one type of system [31].

Throughout the literature, there are numerous proposed solutions to prevent and improve workflow issues and reduce unintended negative consequences of HIT, including improved understanding, feedback, and technological changes. Many call for a more thorough understanding of workflow in clinical settings both before and after HIT implementation [1][24]. This requires us to shift our focus from “planned” use to actual use [23] and consider multiple perspectives when designing and evaluating systems [25]. Some researchers have even proposed frameworks to better understand workflow and HIT integration. For instance, Harrison et al. [23] developed the Interactive Sociotechnical Analysis (ISTA) framework to better understand the healthcare organization as a sociotechnical system and “stop viewing HIT innovations as things, but instead treat them as elements within unfolding processes of sociotechnical interaction” p.543.

Feedback from clinicians and staff is also crucial to making necessary changes and understanding how systems affect work practices and patient care delivery. Providers' feedback should be used to guide HIT design, adoption, and evolution [1]. It is not enough to solicit feedback; we have to take the feedback seriously by improving communication with healthcare providers, integrating their ideas into redesign, and customizing HIT to fit their workflow [24]. This may lessen the negative effects [24]. As part of this feedback, workarounds need to be transparent. By tracking workarounds and making them more visible, we can determine if they are necessary to deliver patient care and then formalize them as part of organization processes [20]. We can also better understand the effects of workarounds, which allows us to better mitigate their risks [20]. The design of systems is not stagnant and thus, we must iteratively make design changes as we learn more about clinical workflow and the effects of HIT [1]. The goal is to make necessary design and policy changes through increased understanding and feedback in order to better support healthcare providers work practices and minimize unintended negative consequences.

4. Future Directions

Translating our understanding of workflow to HIT design and implementation is challenging. Before systems are designed and implemented, we can study work practices in depth. We also may be able to map the workflow of different stakeholders that play a role in patient care delivery. The design of these systems needs to consider the primary consequences, such as workflow issues (like new or increased work, work interruptions and distractions, work delays or inefficiencies, duplicated work practices, and changed or disrupted communication). Then when changes to workflow are inevitable, we need to develop ways to ease clinicians' negative emotions, reduce their cognitive load, alleviate concerns about power and role changes, and ensure they do not become over-reliant on technology. Additionally, the design and use of workarounds has to consider potential impact to patient safety and privacy.

One major challenge is that it is near impossible to have a complete understanding of unintended consequences, especially negative ones, before HIT adoption. Technologies often have to be put in place to see their effects. While we can try to anticipate the changes to workflow and secondary unintended consequences, it is often not until these systems are in place that these issues are brought to light. Therefore, we need strong relationships with system designers, developers, and vendors to make necessary changes to HIT to improve workflow and ease secondary consequences. Systems must be flexible enough to be altered. Those capable of making changes must be receptive to feedback and suggestions, and they need to see their system as a constant "work in progress" in order to maximize the benefits of their systems while minimizing harm both to clinicians (and staff) and patients.

This is a good first step at understanding and unpacking the relationship between what we have termed as primary and secondary unintended consequences. However, in studying unintended consequences related to workflow, we have to take a holistic approach that addresses systems, users, managerial issues, and context and consider the secondary or indirect effects resulting from the primary workflow changes. We hope this chapter sparks more research on the different categories of unintended consequences as well as the causal and perhaps even cyclical connections between them.

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