A HUMAN FACTORS PERSPECTIVE OF INFORMATION FLOW IN HEALTHCARE

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Abstract

Information flow in healthcare is becoming more complex as additional information technology systems are added which may shift the role of the healthcare provider or eliminate signals that aid in planning and/or preparing for an upcoming event. This presentation uses a human factors perspective to focus on how information flows between systems using four criteria: modality, synchronicity, bandwidth, and flow paths. Similarly, the impact on information flow using information technology systems between spatially distributed facilities will be discussed. Finally, event triggers, which signal that specific event conditions have been satisfied, also signify the kind of resource foraging that can take place, (in preparation for, or in response to, an event). The outpatient prescribing process, and more specifically the new prescription and renewal prescription processes, will be used as an example of these concepts.

Introduction

In the 2005 state of the union address, President George W. Bush called for every American to have an electronic medical record by 2015, starting a national push for increased information technology (IT) in healthcare (Bush, 2004; Angst, Agarwal, Sambamurth & Kelly, 2010). Then in 2009, President Barack Obama signed the American Recovery and Reinvestment Act (ARRA) in an effort to continue the development and implementation of health IT. This act designates $59 billion of funding for health information technology (ARRA, 2009). Money from the ARRA created Regional Extension Centers that have been supporting healthcare providers with implementing electronic record systems.

The implementation of these technologies results in a change in information flows. Technology also introduces the possibility for a more proactive approach to manage patient care. Nonetheless, electronic systems such as electronic prescribing systems can introduce another level of complexity to the prescription process rather than just simplifying it.

Outpatient Prescribing

As an example to clarify how information flows in healthcare and the impact of new uses of information technology, the outpatient prescribing process will be examined. In general, the outpatient prescribing process requires the coordination of patients, prescribers, and community pharmacists. An outpatient practice prescriber (physician, physician assistant, and nurse practitioners) decides on an appropriate care plan for the patient. The community pharmacy is then tasked with dispensing the prescription with the corresponding medication for the patient. Figure 1 shows a simplified schematic of the prescription process between the three key players.

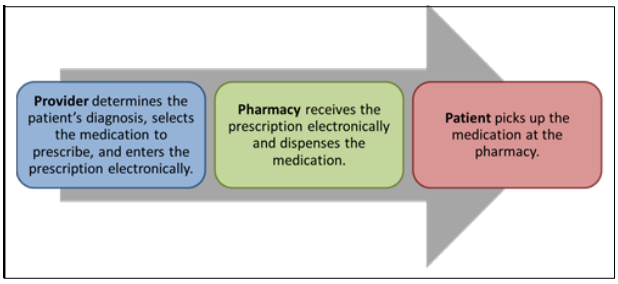

Figure 1. Simplified Electronic Prescribing Process

To coordinate the prescribing process, information and eventually physical resources must flow between these individuals. However the form in which this communication and information flow occurs can happen in a number of different ways, with various tradeoffs in a number of scenarios.

Information Flows

Information exchanged within or between systems can occur through multiple modes. In this section, information flow channels are evaluated by four criteria – flow paths, modality, bandwidth and synchronicity.

Flow Paths

Information can flow between the supplier and the recipient directly (e.g., face-to-face) or through an information technology (e.g., email). Mediated flow paths require some use of technology information to allow information to flow, while unmediated flow paths do not require information technology to transfer the information (Boustany, 2007). Mediated information technology flow paths enable functionality such as a recorded history and the hurdle of both time and long-distance to be overcome. To be used however, both parties must have the appropriate technology available and know how to use it, and the flow path must be properly "maintained" (e.g. available internet connection).

Modality

Modality is the channel through which information is transmitted. The main forms of modality for medication prescribing include auditory, visual, and tactile (Boustany, 2007). A phone call would be an example of an auditory modality, while a paper prescription would be a visual modality for sharing information pertaining to the medication process. A patient taking a pill out of the medication bottle would be an example of a tactile modality.

When information technology is introduced to a system in order to share information, the modality becomes primarily visual using a computer, smartphone, or other mobile technology. When switching the auditory modality to text for exchanging information, some of the implicit information may be lost such as tone (urgency in voice, loudness of message) or emphasis on certain words or phrases.

Bandwidth

Bandwidth is the amount of information that is transmitted over a period of time. A process consisting of learning or education could necessitate higher bandwidth than a quick status update which would require a lower bandwidth. Teaching a new patient about a new medication that they need to start taking would require more bandwidth than the pharmacy notifying the provider that a patient picked up a refill.

Bandwidth can also be described in terms of information richness. According to Rice and Shook, information richness is "the extent to which media are able to bridge different frames of reference, make issues less ambiguous, provider immediate feedback, transmit multiple cues, involve several senses, transmit language variety, or provide opportunities for learning in a given time interval" (Rice & Shook, 1990, p. 199). Face-to-face interactions have the most information richness for a task involving ambiguity, while email was selected for a task involving situational constraints (Rice & Shook, 1990).

Synchronicity

Synchronous communication occurs when two parties exchange messages across a communication channel at the same time (e.g., face-to-face, telephone, online chat) (Coiera, Jayasuriya, Hardy, Bannan, & Thorpe, 2002). The primary advantage for synchronous communication is the ability for immediate feedback and clarification when necessary. An advantage to asynchronous communication is that the communication exchange does not require both parties to participate in the conversation at the same time (e.g., email, fax) and the recipient can deal with communication at a time of his or her choosing. However, this same advantage has the drawback that it is more difficult to know that the receiving party has received and understood the information fully.

Event Triggers

Event triggers are signals that indicate that specific event conditions have been satisfied enabling an individual to identify the system state. The individual then believes that their understanding of the event is accurate enough to be acted upon (Garrett, 2008). For example, a nurse or medical records assistant may check a list of the following day's scheduled appointments to see who is expected to come to the clinic the following day. They may do this in order to pull the patient charts and to review them, possibly to see if all lab results are available for the consultation. The list of scheduled appointments does not guarantee that all of those patients will arrive, but often it will be enough evidence to allow preparation for the future event.

As shown in Figure 2, the event trigger, or state identification, enables specifically tailored resource foraging, both proactive and reactive to occur. Proactive foraging occurs when you start to prepare for the event once you detect the state but before the state has arrived (preparation for a known or expected event, as described in the scheduled outpatient appointment example above). Reactive foraging is once the state has arrived and you then react (when specific resources are sought in response to an emergent event, for example checking for lab results after the patient has arrived for their appointment). These two types of foraging will also be explained in relation to outpatient prescribing, specifically the renewal processes.

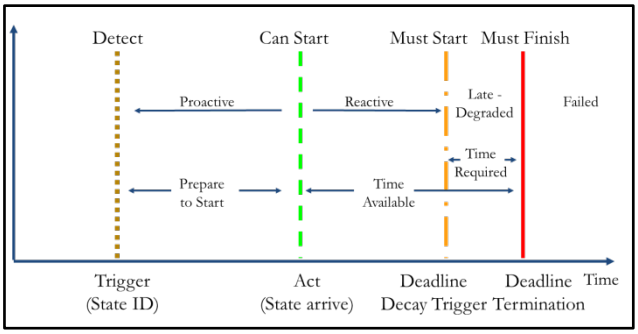

Figure 2. Event Triggers (Garrett, 2008)

Example

Two prescription types (new and renewal) will be evaluated in this paper, but to better understand the prescription process a description of new, refill, and renewal prescriptions will be explained.

New prescriptions are given when a patient has not received a medication before or if they are not currently on a medication. A new prescription is given first time prescriptions for acute and chronic conditions. Within a new prescription, the provider will set a fixed number of refills that the patient can continue to retrieve from the pharmacy. Refills are prescribed given that the provider

deems multiple refills necessary. The refill process does not normally include the provider and mainly occurs between the patient and the pharmacist. After all the refills have been filled, a medication can be renewed. A renewal is normally initiated by the pharmacist or patient, but the prescription must be completed by the provider and the prescription process is similar to a new prescription, but the event triggering is drastically different.

Information Flow

As shown in Figure 3, for the new prescription process, a provider has to decide on a medication and then there is a decision as to how the prescription will make it to the pharmacy. Information related to the prescription can flow in three different manners – paper, voice, or digital. For voice and digital, the provider contacts the pharmacy directly.

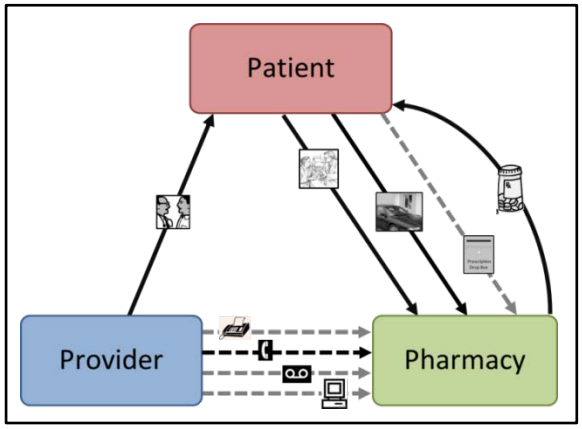

Figure 1. New Prescription Information Flow

Table 1 shows an example of the information flow media that can be used for a new prescription based on mediation and synchroneity.

Table 1. Information Flow Media for New Prescriptions

Mediation	Synchroneity	Information Flow Media
Unmediated	Synchronous →	Face-to-face
		Drive-thru
	Asynchronous →	None
Mediated	Synchronous ⇢	Phone call
	Asynchronous ⇢	After-hours drop-box
		Fax
		Voicemail
		Electronic prescription

Prescriptions given to the patient can be taken to the pharmacy where the patient can take it in the store (unmediated synchronous), take it through the drive-thru (unmediated synchronous), or leave it in a drop-box (mediated asynchronous). In some cases, the provider may directly share the information with the pharmacy through a phone call resulting in direct communication (mediated synchronous) or leaving a voicemail (mediated asynchronous). The provider can also send the prescription by fax (mediated asynchronous) or by electronic prescribing (mediated asynchronous).

In the situation of a prescription renewal, additional information flow media may also be available to initiate the process such as e-mail, the pharmacy's phone tree or an online form (website).

Event Detection – Trigger Example

For the event trigger example, the renewal prescription process will be utilized. For a renewal to be triggered, one of the key players needs to take action. However, just like the new prescription, only the provider can make the decision to renew the medication. Then the process is similar to new prescription process with the exception of the acceptance of a renewal request via the electronic prescription system.

For the renewal process, there are six different paths that can occur as shown in Figures 4 – 6 depending on who initiates the process and whether the request goes directly to the healthcare provider or through the other party first.

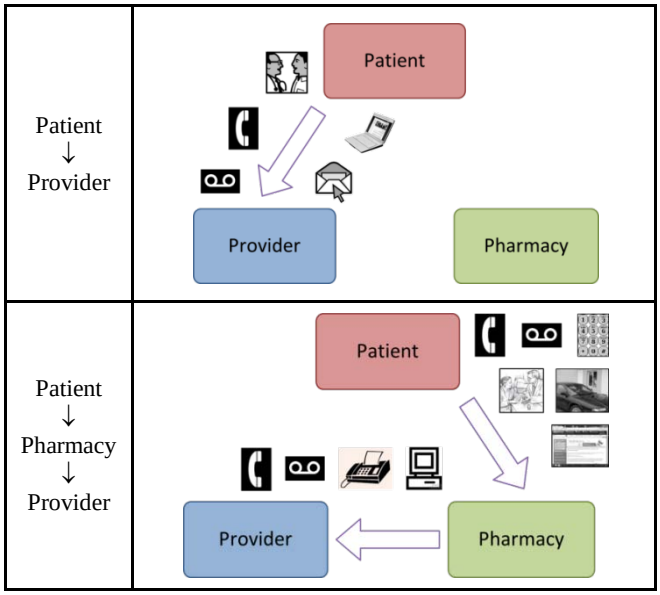

Figure 2. Renewal Prescription Information Flow starting with the Patient

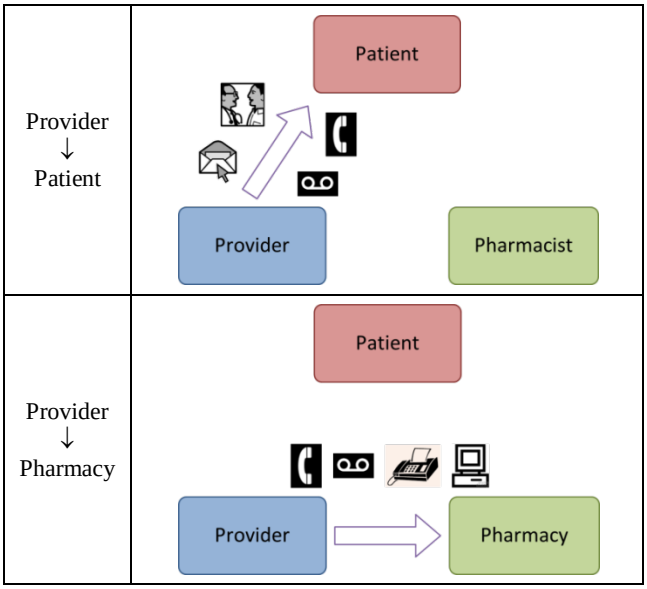

Figure 3. Renewal Prescription Information Flow starting with the Provider

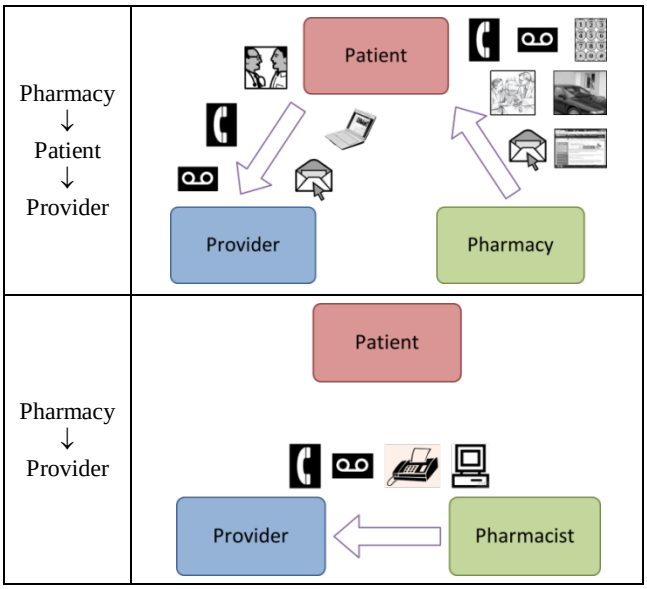

Figure 4. Renewal Prescription Information Flow starting with the Pharmacy

Impact of Information Technology on Event Detection

With the implementation of new health IT, an opportunity exists for the provider and the pharmacy to use technology for improved event detection and thus proactive foraging. In the outpatient example, a provider's electronic health records could alert the provider that the patient should be low on their medication and an appointment should be scheduled or a prescription needs to be sent to the pharmacy. A pharmacy could also alert patients (via email, text message, phone, etc.) to let them know that they are out of refills and they must contact their provider to get a renewal prescription. In both of these examples, the provider and pharmacists can use technology to proactively complete the renewal prescription rather than waiting for the patient to alert them when the patient is out of medication which would be a more reactive situation. Table 3 provides examples of each key player's proactive and reactive event detection.

Table 2. Proactive and Reactive Event Detection in the Outpatient Settings

	Patient	Provider	Pharmacists
Proactive	Patient sets up and goes to an appointment with provider before medication runs out.	Provider is alerted by electronic system to schedule the patient an appointment before medication runs out.	Pharmacy electronic system alerts patient or provider that medications will either 1) expire or 2) no refills are remaining on prescription.
Reactive	Patient runs out of medications.	Patient notifies provider after running out of medication.	Provider or patient alerts the pharmacy that the patient is out of medications.

Conclusions

A significant goal of electronic medical record implementation and increased health IT usage is improved patient safety and care continuity. If implemented well, this should be possible in the context of the outpatient prescription process as described in this paper.

It is important to determine which event triggers are necessary to identify in order to effectively prepare for future events to ensure that the implementation of new technology does not reduce, confound or eliminate important signals. Effective technology use should make the relevant signals more explicit and salient, for example having automated reminders sent when a prescription is due to run-out, with no remaining refills. It is our hope that with appropriate attention to detail during the technology selection and implementation phases, the flow of information can be supported improving the care able to be given to patients.

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Biographical Sketch

Sandra Garrett is an Assistant Professor of Industrial Engineering at Clemson University in South Carolina. She received her PhD and MS degrees in Industrial Engineering from Purdue University, and her BS in Industrial Engineering from Clemson University. Her research in human factors engineering has taken a holistic, cross-disciplinary approach, exploring theoretical issues in information flow and knowledge development within complex environments, team coordination and healthcare systems engineering. Sandra has been working in healthcare systems for over 6 years with experience in both outpatient and hospital settings, as well as working with state and local public health department. Sandra has been a member of IIE since 1997 and is involved in HFES and ASEE.

Ashley Benedict is a PhD candidate in Industrial Engineering at Purdue University in West Lafayette, Indiana. She received her BS and MS degrees in Industrial Engineering from the University in Florida. Ashley worked as a management engineer for Shands HealthCare for three years after receiving her BS degree. She is currently working with Dr. Barrett S. Caldwell and her research is focused on how electronic prescribing systems impact communication between healthcare providers, pharmacists, and patients based on the prescription type. Ashley has served as a session chair for SHS Conference for the past five years. She is also involved in HFES, ASQ, and ASEE.