

# Longitudinal Remote Follow-Up by Intelligent Conversational Agents for Post-Hospitalization Care

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## Abstract

After a hospitalization, approximately 1 out of 5 patients will suffer from an adverse event, and one-third of these complications are preventable. Having a pharmacist follow-up with patients a few days after leaving the hospital has been shown to significantly reduce re-hospitalizations and adverse drug events. In this work, we describe our design for an Embodied Conversational Agent system for longitudinal, post-hospitalization follow-up. We discuss how best-practice follow-up interactions between patients and clinical pharmacists inform the design of our system, focusing on the strategies used by the pharmacist to detect and resolve issues that have occurred post-hospitalization.

## Introduction

The inpatient transition from hospital - to home - to first follow-up with a primary care provider represents a gap in the U.S. healthcare system that is largely neglected, highly error prone, and, until recently, non-standardized. Because of these shortcomings, 1 in 5 patients get readmitted to the hospital within 30 days of discharge, and studies have shown that one-third of these readmissions are typically preventable (Forster et al. 2003) These unnecessary readmissions represent a significant burden to our health care system in terms of costs and resulting morbidity and mortality to patients.

A few interventions, developed and evaluated in randomized clinical trials, now show promise for reducing the 30-day hospital readmission rate. These interventions typically involve a nurse or pharmacist calling patients a few days after discharge to determine if they are having any problems or complications that can be resolved, or if they have questions or uncertainties about their self-care regimens, particularly regarding their medications. The Re-Engineered Discharge (RED) project at Boston Medical Center is one such intervention that was shown to reduce

re-hospitalizations by 30% (Jack et al. 2009). In 2007, the National Quality Forum “Safe Practice” update highlighted hospital discharge as a critical area of improvement, and outlined safe practice guidelines based largely on components of the RED program (National Quality Forum, 2007). Important elements of this protocol include: 1) printing discharge instructions in a format that patients (including those with low health literacy) can understand; 2) reviewing these instructions in detail with patients prior to discharge; 3) testing their comprehension; and 4) having a nurse or pharmacist call patients a few days post discharge to resolve any issues.

While in-hospital education is unquestionably important and beneficial to patients, another critical factor in achieving positive health outcomes is post-hospitalization follow-up with patients. Follow-up phone calls by a nurse or pharmacist may be essential to a safe transition from hospital-to-home. One European study of community pharmacists reported that 64% of recently discharged patients evaluated had medication issues (Paulino et al. 2004). In the RED project, the study pharmacist performed at least one corrective action for 59% of the patients reached, and found that 65% of patients who completed a medication review on the phone had at least one medication problem (Jack et al. 2009). Several studies have shown that post-discharge interventions, specifically by pharmacists, can reduce Emergency Department (ED) visits and re-hospitalizations, and also reduce preventable adverse drug events (Al-Rashed et al. 2002, Dudas et al. 2001, Schnipper et al. 2006).

With post-hospitalization follow-up being an important factor in health outcomes, our goal is to create an intelligent at-home system that can work with patients to prevent and detect post-hospitalization adverse events. We are designing an ECA system for patients to use at home, after a recent hospitalization. The goal of this system is to emulate the role of the post-discharge phone call by the clinical pharmacist in Project RED. The system focuses on medication and follow-up appointment adherence, as well as screens for post-hospitalization adverse events.

To inform the design of this system, we audiotaped a series of follow-up conversations between the RED project pharmacist and recently discharged hospital patients. In this paper, we present a content and discourse analysis of transcripts from these sessions, and discuss how the findings have been incorporated into the design of our ECA system for post-hospitalization follow-up.

## Background and Related Work

Automated telephony systems for home health monitoring have been used to interview patients about their health (Friedman, et al. 1997). These dialogue systems utilize Interactive Voice Response (IVR) technology to allow patients to conduct a simulated conversation, responding to the system using either speech or DTMF (touch tone) input. A downside of these systems is that they place a large amount of cognitive load on users. At each turn of the conversation, users must remember the list of acceptable responses given by the system, which can often lead to confusion and frustration.

Home-based devices and sensors have also been used by patients to self-report their health status. These devices can range from scales and blood-pressure monitors where patients self-report their results over the phone, to web-enabled devices, such as the Health Buddy in which patients answer a series of daily health questions that are automatically reported to a case manager for review (Cherry et al. 2002). More advanced devices, such as the LifeShirt, incorporate sensors into clothing to create a wearable device that monitors the vital signs of patients during their day-to-day activities (Grossman 2004). Unfortunately, many of these systems can be prohibitively expensive, and lack long-term empirical evaluations on their effectiveness.

## Embodied Conversational Agents for Patient Education

Evidence suggests that face-to-face encounters with a health provider, in conjunction with written instructions, is one of the best methods for communicating health information to patients, especially to those with inadequate health literacy (Houts et al. 2006, Morris, Halperin 1979). Embodied Conversational Agents (ECAs) are animated virtual humans that incorporate both verbal and non-verbal cues to simulate face-to-face conversation (Cassell, 2000), and they provide a particularly compelling interface modality for patient education (Figure 1). First, they are easy to use, requiring no prior computer experience. Second, they are based on computational models of natural human behavior, which allows for rapport-building and empathy, important factors in positive health outcomes. Third, ECAs can provide health information that is adapted to the particular needs of a patient and to the immediate context of the conversation, and also function in a low-pressure environment in which patients are free to take as much time as they need to thoroughly understand the

information being discussed. Last, they have been successfully used in underserved populations such as older adults, and people with inadequate health literacy (Bickmore, Caruso and Clough-Gorr 2005).

In our automated implementation of the project RED protocol, we used ECAs in order to simulate the effects of face-to-face patient education by a nurse at the time of hospital discharge. The ECA had a digital rendering of the patient's personalized discharge booklet and was able to bring up pages of the booklet on the screen and teach the patient about their personalized plan, with the patient being able to follow along in their paper copy of the booklet. In a pilot evaluation, patient indicated high levels of trust in and satisfaction with the system, reported that the interaction helped prepare them to leave the hospital, and only 16% of them indicated they would have preferred receiving their discharge instructions from a doctor or nurse in the hospital. A 750-patient clinical trial of this system is underway (Bickmore, Pfeifer and Jack 2009).

## ECAs for Long-Term Patient Follow-Up

We are currently designing an at-home system for post-hospitalization patient follow-up, based on our analysis of best practices by the clinical pharmacist in our observational study. The goal of this system will be to provide an easy-to-use mechanism for a recently hospitalized patient to track their adherence to their discharge plan, report any adverse events (such as medication side effects) that have occurred at home, and receive education and counseling regarding their health condition, medication regimen and follow-up appointments. The system will be a web-based extension of our ECA system for in-hospital education, to provide a familiar and accessible interface for patients (Figure 1).

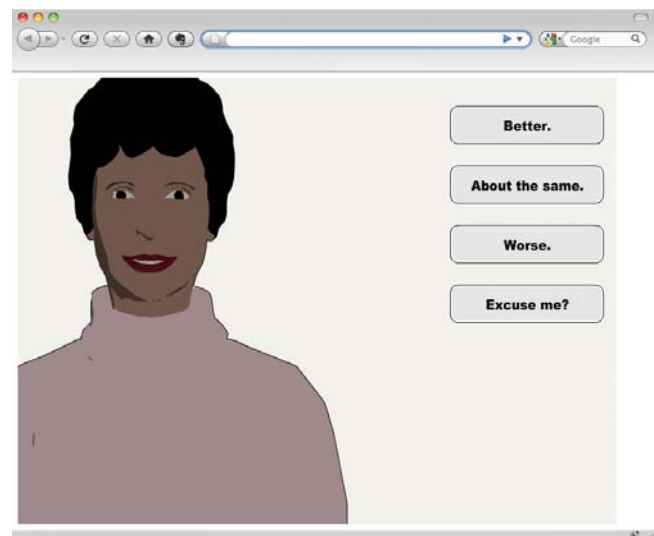


Figure 1. Web-based ECA for longitudinal post-hospitalization follow-up

**Table 1. Patient-Pharmacist Conversational Detail**

	Conversation Length	Percent of talking done by the patient	Number of medications discussed	Number of issues discovered	Number of questions the patient asked
<b>Patient 1</b>					
First conversation	74 minutes	49%	11	5	10
<b>Patient 2</b>					
First conversation	68 minutes	41%	11	4	0
Second conversation	66 minutes	47%	11	2	0
<b>Patient 3</b>					
First conversation	58 minutes	49%	15	4	0
Second conversation	29 minutes	50%	16	2	0

**Condition Review**

Ok, so first can you tell me the main reason why you were in the hospital? *Ummm, I was having shortness of breath...and there was also, they found fluid on my lungs which might have been caused by a virus and it might have affected my heart.* Perfect, yep, right that's exactly the information that I got. Because of that virus around your heart, maybe your heart wasn't pumping as efficiently and your blood pressure was high, so they said that maybe you had some cardiomyopathy. That would be the diagnosis.

**Medication Review**

So how do you remember to take your medicines? Are pill boxes usually... *I just line 'em up. What I do is I put my diabetes medicine on one side, and then the others I just line 'em up and take them one-by-one.* OK, and that system seems to be working for you? *Yeah.* So whenever you're ready I'll have you just take one medicine at a time and we'll go through 'em. I'll compare it to the list I have here and I'll ask you a couple questions about each medicine. So, in any order that you want... *Fffffurosemide....* Yep Furosemide good. *I think this the fluid pill.* That is the fluid pill. *I take it in the morning.* OK and how many tablets do you take in the morning? *One.*

**Side-Effect Discussion**

Any side effects from this one? This is probably causing your headache, yeah. *It's not that bad it's like in the back here.* OK, how bad is the headache and how often does it come? *It's not too bad, it's tolerable, just annoying.* OK, so on a scale of say zero to ten, zero is no pain and ten is like the worst headache of your life, where would you put it? *Three.* You would put a three, ok and when you get the headache what do you usually do?

**Appointment Discussion**

Now when are your upcoming appointments? *I have one with the heart specialist on the 9th, and one with my primary care on the 20th.* Perfect so on the 9th you're going to see Dr. \_\_\_\_\_ the cardiology doctor at nine in the morning. Do you know where to go for that? *Yep.* Are you going to be able to make that appointment? *Yes.*

**Figure 2. Sample patient-pharmacist dialogue for routine aspects of the conversation (edited for grammar)**

The most challenging of the system's features to design is the detection of adverse events, specifically, medication adherence issues and side effects. Our research team was concerned that patients might be more likely to (falsely) report that they were taking their medication exactly as prescribed, if interacting with a computer system rather than a person. Additionally, our team worried that patients might over-report instances of medication side effects.

In order to inform the design of our system, we studied follow-up conversations between patients and a clinical pharmacist at the hospital. We investigated the distinct techniques used by the pharmacist to detect issues that the patient might be experiencing, post-hospitalization. Several research questions were of particular interest: R1) How did the pharmacist structure her conversation with patients? R2) What problems did the pharmacist uncover

and how were they resolved? R3) Did the patients ask the pharmacist any questions? If so, what information did the patients want to know?

In order to answer these questions, we observed and analyzed five conversations between a clinical pharmacist and a recently discharged hospital patient. We describe our analysis of those conversations and discuss how our findings can be used to inform the design of an intelligent system for at-home follow-up with patients.

**Patient-Pharmacist Conversations**

Three patients participated in the observational study; recruited during their hospitalization. Participants were asked to return to the hospital a few days after discharge, and meet one-on-one with a pharmacist to discuss how

they are doing at home. If possible, participants scheduled a second follow-up visit with the pharmacist, and two participants were able to do this. Participants were paid \$25 for each visit. All conversations between the patients and pharmacist took place in a small hospital conference room, were audiotaped and were fully transcribed. We also conducted a separate interview with the pharmacist, to review the transcriptions from the patient sessions, and discuss her motivation and rationale behind particular topics discussed with the patients.

### **Conversational Structure**

The conversations between the patient and pharmacist followed a structured plan, and were generally pharmacist-driven. A summary of the conversations is listed in Table 1 and a typical outline of the conversations is shown in Figure 2. Prior to the first conversation, the pharmacist reviewed the patient's hospital discharge summary to familiarize herself with the patient's case and discharge instructions. Upon meeting the patient, the conversation began with an introduction and quickly moved to a discussion about the patient's hospitalization and medical condition. In this portion of the conversation, the pharmacist sought to ascertain the patient's point of view on what led to their hospitalization, as well as to find out if the patient knew their discharge diagnosis. She also asked if the patient had returned to the hospital, Emergency Department or to any clinical appointments since leaving the hospital, in order to determine whether their prescribed medications had been changed since their hospitalization, so that they could be accurately reviewed later on in the conversation.

After reviewing the patient's medical condition, the conversation moved to a discussion about the patient's medications. Patients were asked to bring in all of their prescription medications each session and the pharmacist had them place these medications on a table between them at the start of the session. The pharmacist began by asking the patient about the method they used for remembering to take their medicines and, specifically, whether or not they used a pill-box. Next, each medication was reviewed one by one, with the patient choosing the order in which the medications were discussed. For each prescription, the pharmacist had the patient read the name of the medication out loud, describe how often they took the medication each day, and how much they took at one time. The pharmacist reconciled the patient's information with the information listed on the patient's discharge summary and clarified and corrected any misunderstandings by the patient. This portion of the conversation was typically the longest, taking up 55% of the conversation, on average.

When reviewing medications, the pharmacist would often bring up the subject of side effects. If a patient reported or endorsed a side effect, the pharmacist would find out when it started happening, how severe the patient thought it was, how often it was occurring and whether or not the patient had taken any action to deal with the side-effect. She would then give advice to the patient on how

the side-effect could be handled or avoided, and what action the patient should take if it worsens.

Following the medication discussion, the pharmacist would review the patient's post-hospitalization follow-up appointment with their primary care physician (PCP) and any specialist appointments, if necessary. During this portion of conversations, the pharmacist discovered if the patient understood when and where every appointment was going to take place, who the appointment was with, what it was for, and whether or not the patient was still able to go to the appointment. The pharmacist also discussed emergency situations with the patient, and counseled the patient on situations when they should go to the Emergency Department, and situations when it would be better to contact their primary care physician's office or pharmacy.

Finally, the pharmacist discussed condition self-management with patients. For two of the patients, diabetes self-management was reviewed in detail, discussing how often they should check their blood sugar levels, what their goal level should be, medical terminology related to diabetes, signs of hypoglycemia and explaining what do in an emergency. For another patient, blood pressure was reviewed in detail, including recent lab test results and goals for the patient.

During the course of the conversation, the pharmacist also discussed topics that were unique to each patient. For example, one patient had recently lost his health insurance and had trouble filling his prescriptions. The pharmacist listened to the patient's background on the situation and made any necessary arrangements to ensure the patient was receiving all available assistance.

Two of the three patients in our study were able to return for a second conversation with the pharmacist. These follow-up conversations followed a similar structure to the initial interaction, with the amount of time spent on each topic allocated differently. For both patients, the pharmacist spent 13% of the second conversation explicitly following up on issues that were discovered during their previous session. For Patient 3, who was not able to bring her medications to the first session, but did bring them to the second session, the pharmacist followed almost the same structure the second time around, spending 54% of the time reviewing medications and 8% of the time on education regarding the patient's medical condition. For Patient 2, the pharmacist altered her approach during the second session, changing the time spent discussing medications from 52% to 25% and increasing the amount of time spend on condition education from 7% to 26%.

### **Issues Detected by the Pharmacist**

During each session the pharmacist detected, on average, 3.4 problems. These included patients who had misunderstood how often they were supposed to take their medications, experiences with medication side effects, confusion about dates/times of follow-up appointments and lack of disease self-management.

With our goal of building an at-home system for the detection and monitoring of adverse events, we were particularly interested in how the pharmacist uncovered these issues, how she attempted to resolve them, and if the patient was compliant in following the pharmacist's recommendations. In this section, we discuss the different classes of problems detected and the various courses of action taken by the pharmacist.

**Patients Following a Different Medication Regimen than Prescribed.** The most common problem detected by the pharmacist was the patient taking their medicine different than prescribed. This issue is deeply complex, and cannot be attributed to one simple cause. Previous work has shown that a wide-variety of factors can influence medication adherence, including forgetfulness, deciding to omit doses, lack of information, and emotional factors (Osterberg and Blaschke 2005). In our observations of the patient-pharmacist conversations, two examples of non-adherence emerged.

In the first example of non-adherence, the patient had their prescribed medicine at home, was taking the medicine, but was not taking it according to the physician's orders. For Patient 1, this seemed to be a case of non-intentional non-adherence: the patient simply misunderstood how often to take three of his medicines. This patient had seven medicines that were prescribed for two times/day, two medicines to be taken once/day, and one medicine to be taken three times/day. It turned out that patient was taking all medicines twice daily. For this situation, the pharmacist corrected the patient, and checked for patient understanding by having the patient repeat back the correct times of day for the medications that were not being taken correctly. At the end of the conversation, the pharmacist reviewed the correct times to take each medicine, to reiterate the prescribed plan.

Patient 2 had a similar situation, with a medication prescribed for twice a day, but the patient was only taking it once a day. However, in this instance, the *patient* was correct, and the *discharge summary* was incorrect. The particular medication was for diabetes, and prescribed according to the patient's blood sugar levels. When leaving the hospital, the patient was told to take the medicine once a day, and was following that order. The information in the discharge summary listed the medication as twice per day, and was either entered incorrectly or had not been updated to reflect the most recent information. After discussing the patient's blood sugar levels with the patient, the pharmacist realized that the error was most likely on the side of the hospital's entry, not on the side of the patient. The pharmacist recommended continuing to take the medicine one time per day, called the patient's primary care office and had an appointment made for the patient in order for the PCP to test the patients blood sugar levels and assess the correct medication level for that patients. When the patient returned for their second session, the pharmacist asked the patient to review what the primary care physician

recommended, and discovered that indeed the medication should only be taken only once per day.

In the last example of non-adherence, the patient did not have the prescribed medication, and thus was not taking the medication. This included new prescriptions made during the recent hospitalization, as well as standing prescriptions that were never refilled. Patient 3 was not able to bring in her medications during the first session with the pharmacist, but the pharmacist still went through each medication on the discharge summary one-by-one to discuss it with the patient, determining if the patient recognized the medication by name, and whether or not the patient was taking it as prescribed. During that conversation, the patient stated that they never received the paper prescriptions for two of their medications prescribed during their hospitalization and that for another previously prescribed medication, she had not refilled it for over a year. The pharmacist had discovered early in the conversation that the patient had a follow-up appointment with a nurse practitioner that same afternoon, so she gave the patient a detailed printout listing medications for which the patient needed new prescriptions, for the patient to bring with to her appointment. During second session with the pharmacist, Patient 3 was able to bring in her medications and the pharmacist and patient were able to review them together more thoroughly than during the previous session. During this follow-up conversation, the pharmacist discovered that for one of the medications that the patient thought they didn't have, they in fact did have it and were taking it as prescribed. For the other two medications, they had still not picked them up from the pharmacy and were not yet taking them. In addition, a few days earlier, this patient had been re-hospitalized for breathing problems, and upon discharge was prescribed a steroid to begin taking immediately. Unfortunately, the patient had not yet filled this prescription.

**Medication Side Effects.** The pharmacist also frequently detected side effects that the patient had experienced at home. For fifty-seven percent of all medications, the pharmacist specifically asked about possible side effects. Each patient endorsed at least 1 side effect during the conversations. Of the 5 total side effects detected, one was detected by the patient self-reporting the issue after the open-ended question, "Do you think you are having any side-effects from this medication?" another was detected by a closed-ended question ("Any dizziness?") and the remaining 3 side effects were detected by mentioning that a specific side effect is possible and then asking if the patient had experienced it, such as "Sometimes when people start taking this they feel tired, are you feeling tired?"

The pharmacist's choice for framing and asking about side effects seemed to vary by patient. For example, the technique of asking the open-ended question "Are you having any side effects?" followed by mentioning and teaching about a specific side effect that can occur with the medication and then asking if the patient had experienced

that specific side effect, was almost exclusively used with Patient 2. During the beginning of the medication discussion, the pharmacist would ask each patient if they knew why a particular medicine being discussed was prescribed for them, and Patient 2 was the only one of the three who indicated he did not. Thus, for this patient, the pharmacist approached the discussion as teachable-moment, taking the opportunity to explain not only what each medication is for, but also how it works, and what side effects to be aware of.

As mentioned earlier, anytime a patient endorsed a side effect, the pharmacist would find out how often it was occurring and how bad the patient thought it was, in order to help inform her recommended course of action. For all of the side effects that the patients endorsed, the pharmacist encouraged monitoring and follow-up within a few days. For some, she also recommended a specific course of action, such as an over-the-counter remedy (for the headache) or switching their medication from morning to the evening (for drowsiness).

When interviewing the pharmacist about the patient sessions, we were particularly interested in the 43% of medications in which she did not ask about any side effects. It was often the case that these were over-the-counter (OTC) medicines rather than prescription medicines. If a side effect for an OTC medicine was potentially serious, such as bleeding with aspirin, the pharmacist did mention it to the patient, but most often side effects were not mentioned with OTC medicines. In other scenarios, the pharmacist often grouped medications together by indication, and if for example, the patient was on several medications for blood pressure, and dizziness was the most common or serious side effect for all of those medications, the pharmacist would ask about it one time, for one of the medicines, and not bring it up for the rest.

If the pharmacist did bring up the topic of side effects, she almost always mentioned only one of the several potential side effects for that medication. As most conversations were over an hour long, the pharmacist explained her decision to keep things as brief as possible and prioritize the most important side effects for discussion.

I think some of it has to be on the onus of the patient to say 'I think this [side effect] is going on, and I think it might be attributed to a med, do you agree?' If they don't [bring anything up], I just try to go through the things that are life-threatening, that would send them back to the ED, or where I wouldn't want them to continue to take the medication.

**Patient Self-Care Regimens.** Two of the problems detected by the pharmacist regarded self-care and management of their health condition. Patient 2 was instructed to weigh himself daily in order to monitor the effects of his blood pressure medication, however the patient did not own a scale. In this situation, the pharmacist called and left a message with his primary

care doctor's office, on behalf of the patient, to see if they would be able to give him a scale prior to his appointment.

In her first conversation with Patient 3, the pharmacist discovered that the patient was not monitoring her blood glucose levels. This patient didn't want to experience the pain of pricking herself, had an aversion to needles, and didn't want to be thought of as a "junkie". The pharmacist reviewed the importance of self-monitoring with the patient, educated about her glucose goals, and most importantly for this patient, how to recognize signs of hypoglycemia and what to do in an emergency. The pharmacist encouraged the patient to try to check her blood sugar once per day

### **Patient Questions**

Of the three patients in our study, only one asked the pharmacist questions during their session. This patient asked several questions throughout the conversation, mostly as questions for clarifying or additional information from the pharmacist. For example, after the patient asked the pharmacist to point out which medication name was the generic name and which was the brand name. In another example, after the patient asked the pharmacist to explain which side effects could be caused by one of her medications. Other questions included asking whether or not a medication should be taken with food, and about the causes of particular side effects.

### **ECA System Design**

In this section, we discuss the design decisions for our follow-up system, based on the information gathered from the patient-pharmacist interactions.

#### **Teach Back**

One conversational technique we have designed into our system is the teach-back method for testing patient understanding (Bertakis 1997, Schillinger et al. 2003). This method involves having the patient "teach" providers about their health information, and provides an excellent way to determine whether or not the patient understands the information given by their provider. In our study, the clinical pharmacist used this technique, almost exclusively, especially when discussing the patient's medication regimen. Instead of asking, "Are you taking this medication twice a day, one pill each time?" making it easy for the patient to simply say "Yes," the pharmacist asked the patient to tell her when and how much they were taking. This allowed for an increased assessment of the patient's understanding, and also provided a higher likelihood of detecting a problem, if one existed.

## Side Effect Discussion

When discussing medication side effects, we found that the pharmacist usually asked the patient about one particular side effect. Having an automated system determine which side effect to discuss is a challenging problem. On the one hand, the system should be as accurate as possible: one approach would be to list and discuss all possible side effects for each medication. On the other hand, the system should also be as relevant as possible, and not discuss superfluous information with the patient. Another factor is patient engagement: if the conversation becomes long or irrelevant, the patient may become disinterested and stop using it all together.

In our approach, we seek to strike a balance between providing accurate and relevant information, while reducing the chances of overwhelming the patients (Figure 3). For each medication in our database, we had clinicians enumerate the top-five side effects for the system to discuss. These side effects are the most common, or the most likely to be life threatening. Prior to discussing medications with the patient, the ECA displays 20 common adverse events, determined by (Forster et al. 2003), in a checklist format, and allows patients to report if they have experienced any of those events since leaving the hospital. This information will allow the ECA to reduce the number of side effects mentioned for each medication. For example, if the patient denies that they have experienced any headaches during the initial Forster checklist, and the patient is taking a medication with headaches as a potential side effect, then the ECA will not need to ask about that side effect when reviewing those medications. Likewise, as the ECA discusses each medication and we acquire more knowledge about side effects that the patient is or is not experiencing, this will influence the side effects we need to discuss with different medications later in the conversation. We have also incorporated a mechanism for the patient to self-report any side effect that they believe they are having, whether it is tied to a medication in our database or not. This allows us to keep the side effect conversation short and relevant, while also maintaining expressivity by the patient.

## Repeated, Adaptive Interactions

The system is designed for daily interactions to transition patients smoothly from their hospitalization to their primary care follow-up appointment, with its behavior continuously adapted based on prior interactions with the patient and the actions of clinicians monitoring the system. In designing the conversational structure for repeated interactions with the ECA, we are following the approach of the clinical pharmacist to keep the interactions short, and focus heavily on issues that need follow-up. We are also allowing flexibility for the patient to be able to ask questions and find out more information if they so desire.

In order to for the system to effectively discuss follow-up issues with patients, we are designing a back-end alert

management system for a nurse on the clinical team to resolve any issues detected by the ECA. The ECA system is by no means designed to provide traditional medical care to the patient, and as we build and evaluate this system, we believe it will be important for a medical expert to review the issues that the ECA uncovered, work to resolve them (e.g. calling the patient's physician to clarify any misunderstanding about medication dosage), and provide feedback to the patient on the status of that issue. We are designing the ECA to be aware of if and how the issue was resolved, with the ability to discuss the resolution and recommended course of action with the patient.

1. For each medication  $M_i$  load the associated side effects into a list  $SE_i$
2. Display the 20-item adverse event checklist to the patient and collect responses
  - a. For each item  $f$  from the checklist that was not endorsed by the patient
    - i. For each medication's side effect list  $SE_i$  check to see if  $f$  is a member and if so, remove it from  $SE_i$
    - b. For each item  $f$  that was endorsed by the patient, do full side effect assessment
3. For each medication  $M_i$  that the patient has acquired and is taking, present the list  $SE_i$  to the patient and collect responses
  - a. For each side effect  $j$  in  $SE_i$  that was not endorsed by the patient
    - i. For each medication side effect list  $SE_{(i+1)} \dots n$  check to see if  $j$  is a member and if so, remove it from  $SE$
    - b. For each side effect  $j$  that was endorsed, do full side effect assessment

Figure 3. Algorithm for the ECA side effect discussion

## Conclusion

Patient transitions from the hospital to the home are highly error-prone and can often lead to unnecessary complications. These preventable adverse events not only burden our health care system, but can also severely and negatively impact patient lives. Many interventions have shown that a follow-up phone call by a nurse or pharmacist can significantly reduce the amount of unnecessary adverse events and re-hospitalizations.

In this paper, we presented a content and discourse analysis from follow-up conversations that a clinical pharmacist conducted with three recently discharged hospital patients, in order to inform the design of an automated at-home system for patients to use post-hospitalization. We discussed the structure and techniques that the pharmacist used in her conversations with patients, especially with regards to medication adherence and side effects. Finally, we presented our design of an Embodied

Conversational Agent system for at-home monitoring and detection of adverse events.

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