Improving medication compliance with ingestible sensors

BHI 505: Digital Health

Presentation By: Joseph Miles, PharmD
Why Medication Compliance?

- Noncompliance has been reported in 50% of patients taking chronic medications.
- Noncompliance is associated with up to $300 billion in avoidable healthcare costs annually in the US alone.
- Previous methods of increasing compliance have been ineffective
  - Or require frequent (daily) interventions from Healthcare staff
Prescription Non-Adherence Rates

- First-time Prescriptions never filled: 28%
- Pain Medications never filled: 65%
- Total Prescriptions never submitted to pharmacy for filling: 24%
- Prescriptions for Chronic Conditions (e.g., Diabetes, high blood pressure) never filled: 31%

Prescription Non-Adherence Results

- Hospitals and Long-Term Care Facility Admissions related to non-adherence: 20%
- Deaths Per Year attributed to non-adherence: 125,000
- Higher Rate of additional Heart Attacks for heart attack survivors: 80%
- Additional Costs to the U.S. healthcare system: $2,000 per person

Prescription Non-Adherence Reasons

- Don’t Understand Need for Medication
- Can’t Afford Medication
- Forget to Take Medication
- Personal Beliefs Against Taking Medication
- Don’t Understand How to Take Medication

Patient Advisor

888-DRFIRST (373-4778) | Sales@DrFirst.com | www.DrFirst.com

Medication adherence data sources can be found at http://patientadvisor.drfirst.com
Novel Method For Increasing Compliance

- **Sensors!!!**

Simple 3 part system:
- Edible sensor
  - FDA Approved
- Wearable patch sensor
  - Detects ingested sensor
  - Also tracks user activity level, etc
- Interface with mobile device via Bluetooth
The Proteus System ([http://www.proteus.com](http://www.proteus.com))
Sensor Network for Increasing Compliance

- Mobile device reminds the user when medications are due to be taken.
- Device also tracks when and what has been taken (from patch sensor).
- What happens when someone takes their medication and then sees the dose reminder on the mobile device?
Study Evaluation
Study Design

Categories of observed events

- Hypothesis 1:
  - System improves compliance
- Hypothesis 2:
  - System does not cause people to take too much medicine
- Post hoc analysis
- No control group reported
Adherence Improved?

Note about “seeing” and “notseeing”:
It would be more accurately titled as “within Bluetooth range of mobile device” and “not within Bluetooth range of mobile device”

Less adherent subjects increased adherence the most
Adherent versus Adherence

What is in a name?
• Is someone taking a medicine 3 out of 5 days 60% adherent or nonadherent?

• What is the long-term effect on adherence?
• Is the expectation that people would use this sensor system indefinitely?
  • Cost?
  • Compliance with the system?

What's in a name? That which we call a rose by any other name would smell as sweet.

William Shakespeare

Control group data???
Safety of the dose reminders

- 8236 data points recorded assessing overdosage
  - 6 events were actual overdosage.
  - The 6 events happened when the user was “not within Bluetooth range.”
  - Mobile device reminder was determined to be not the cause.

- Upper limit of CI for overdose events was reported as 0.143%

- First, do no harm.

Note:
- FDA approved
- Not only study of the system
Usability

- Over 50% of research subjects made less than $20,000 a year income.
- Over 25% had not graduated high school.
- Noteworthy because usability of the system was rated highly by the research subjects confirming that the system interface is relatively user-friendly.
Study Conclusion

- The authors report on a novel sensor system for increasing compliance in a safe and effective manner.
- The study effectively increases awareness of using ingestible sensors.
- Safe and apparently user-friendly.
- The authors successfully set the stage for prospective studies to further analyze the clinical usefulness of the studied sensor system.
How else can this system be used?

- Compliance with as needed medication!
“Med Conformity” Project

UserProfile

fName [1]
IName [1]
email [0 .. 1]
phone [0 .. 1]
phoneType (cell|home|work)
phone2 [0 .. 1]
phoneType2 (cell|home|work)
dateOfBirth [0 .. 1]

update()
changeUser()
MedicationInformation
PrescriberAdvocate

Home: Med Conformity

User Profile
MedicationInformation
NextDose
DiscussionSanctuary
Personal Journal
Class Diagram Continued

Medication Information
- drugName [1]
- qtyPerDose [1]
- freqPerDay [1]
- scheduled (1=Y | 0=N) default 0 if Y
  daysPerWeek (default='every day')
- totalDrugName [internal storage]
- totalDrugQty [running total]

Next Dose
- nextDoseDrug()
- nextDoseTime()
- TakeMedication
- setReminder()

Take Medication
- drugName
- qtyTaken
- timestamp

- adjustQty(qtyTaken)
- adjustTime(timeTaken)
- addNote(journal|sanctuary)
- writeUsageHistory()
- addMedicationInformation()
- skipDose()
- postpone('number of minutes')
Full Prod vs. Prototype:
• For example:
  • Full Prod would have capability to add prescriber and patient advocate data, personal journal entries and messages to prescriber and/or advocate
  • Full Prod would use sensors to confirm when doses of medication were taken
• Class segments reflect Full Prod
User Stories

- I am not a huge fan of User Stories, but the process of creating the stories has helped in designing elements of the app.

- All Users:
  - Scenario 0: Taking Medication
    - Given that I am prescribed medication
      - And the quantity of medication I possess has been updated.
    - When I notify Med Conformity that I have taken my medication,
    - Then I am notified of the remaining quantity of medication
      - And new ‘Next Dose’ information is calculated.
Persona: Medication User

As a user of medications,

- I want a tool like Med Conformity
- So that I can keep track of the medications I have taken and when my next dose is due.

Scenario 1: Medication Reminder

- Given that I am prescribed medication
  - And I have loaded the prescribed directions for usage into Med Conformity
  - And the quantity of medication I possess has been updated.

- When I receive a reminder from Med Conformity for my next dose,

- Then I take my prescribed medication
  - And I am updated with my new remaining quantity of medication
  - And then I am notified about my ‘Next Dose’ information.
Persona: Medication Misuser

As a misuser of medications

▪ I want a tool like Med Conformity to track my medication usage
▪ So that my prescriber can be assured that I am using my medication appropriately.

Scenario 3: Taking a Dose Too Soon

▪ Given that I am prescribed medication
  ▪ And I have loaded the prescribed directions for usage into Med Conformity
  ▪ And the quantity of medication I possess has been updated at the insistence of my prescriber.

▪ When I take a dose before the dose was due,

▪ Then I am warned that the dose was too early
  ▪ And I am updated with my new remaining quantity of medication
  ▪ And I am reminded that the amount of medication received will need to last until the date of my next refill.