A Data Science Framework for Mobile Health--Engagement and Outcomes

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Objectives

Knowledge about patient behavior is a critical element for managing chronic medical conditions such as type 2 diabetes. Until recently, data about what patients are doing outside their physicians' offices were limited. Mobile health technology has the potential to collect and process new sources of data, which can then be used to provide real-time coaching to patients and clinical decision support for providers. Our aim was to evaluate our processes for knowledge extraction from patient-generated data in a mobile health platform.

Methods

The first mobile prescription therapy, WellDoc's BlueStar, was launched in 2014 for patients with type 2 diabetes. This platform was designed to collect data that would not otherwise be available to providers. Users interact with the product on their smart phone or via a web portal on their personal computer. Usage is not prescriptive but variable based on a number of factors such as patient interest and the complexity of their diabetes treatment plan.

Figure 1: Mobile prescription therapy information flow: novel patient care paradigm

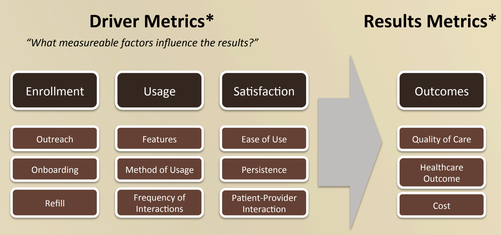
Physician prescribes product to user who has type 2 diabetes. User downloads product onto smartphone. Activation code is provided by a specialty pharmacy. User engages with product on mobile device or desktop PC. Encrypted data is sent to cloud. At patient rquest, the medical provider receives clinical decision support via "SMART Visit" report sent to local FAX machine. This information is available to the medical provider at the time of the next patient interaction.

An active engagement with the product was defined as entry of data such as SMBG, exercise, carbohydrate intake, or medication administration. A passive engagement with the product included watching a video or reviewing the logbook. In this analysis, user data was de-identified in accordance with the HIPAA Privacy Rule. The number and type of user engagements were examined as well as user attributes such as age, diabetes medication regimen, and specialty of medical provider. Preliminary outcomes such as improvements in SMBG were also studied. These data were used to illustrate the utility of our data science framework.

Results

We conceptualized a data framework for mobile health that includes (1) driver metrics, which are measurable factors which influence results and include enrollment, usage, and satisfaction data and (2) results metrics, which examine outcomes such as improved quality of care, improved diabetes control, and potential healthcare cost savings. From March 2014 to May 2015, we identified 1,036 diabetes patients who were prescribed BlueStar, enrolled and activated their accounts, and used the product for over 30 days. We characterized 161,602 active engagements from this population. We report here improvements in SMBG values over time, fewer hypoglycemia SMBG entries, as well as significant reductions in A1C for those users who entered multiple A1C values. User attributes, which are associated with usage and with outcomes, were identified.

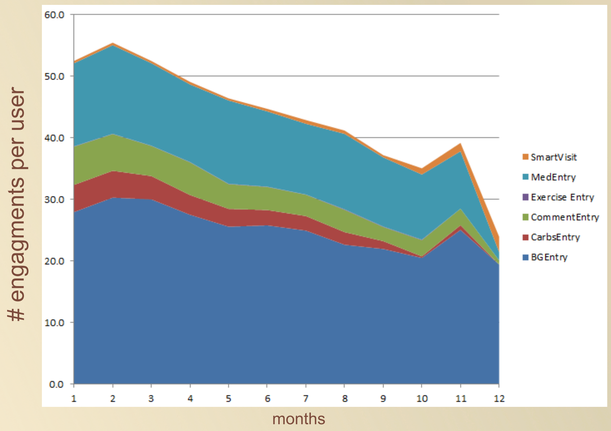
Figure 2: Establishing a framework for measurement in mobile prescription therapy



*Metrics would need to be customized for the specific program and objectives. User may be patient, provider, or any other person who is engaged with the product

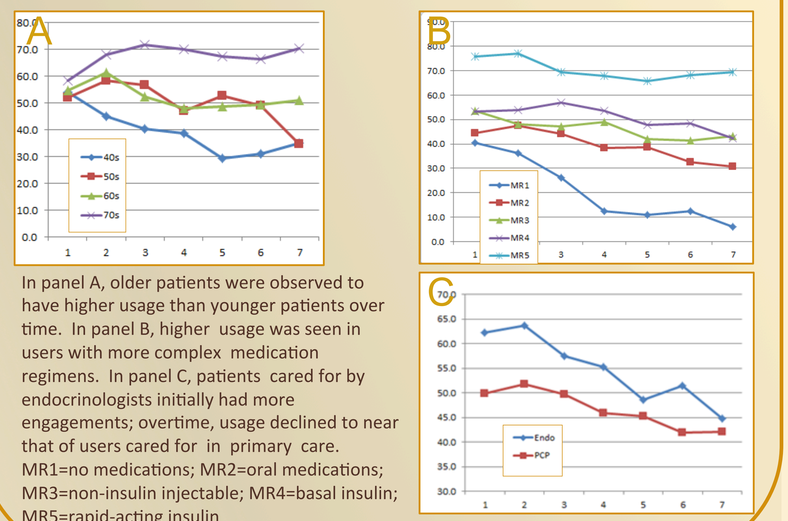
Usage

Figure 3: 1,036 patients who were prescribed the mobile prescription therapy product and used it for greater than 1 month



The most commonly observed active engagement was an SMBG entry. In this product, whenever an SMBG entry is made, the user receives a real-time feedback message which is tailored to the user, is relevant to the user's activity, medication regimen, BG value, and level of curriculum.

Figure 4: Usage by age group (A), medication regimen (B), and provider type (C)



In panel A, older patients were observed to have higher usage than younger patients over time. In panel B, higher usage was seen in users with more complex medication regimens. In panel C, patients cared for by endocrinologists initially had more engagements; overtime, usage declined to near that of users cared for in primary care. MR1=no medications; MR2=oral medications; MR3=non-insulin injectable; MR4=basal insulin; MR5=rapid-acting insulin

Outcomes

Figure 5: Improvements in user BG entries (A), number of extreme highs and lows (B), and self-reported A1C (C)

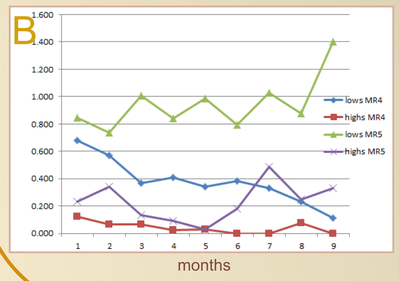
A

A1C (%)	7.1 – 8.0	8.1 – 9.0	9.1 – 10.0	>10
delta BG (mg/dL)	-9.2	-19.0	-14.3	-22.8

medication regimen	MR1	MR2	MR3	MR4	MR5
delta BG (mg/dL)	-1.5	-8.1	-8.0	-17.6	-18.5

Age (years)	<46	46 - 55	56- 65	>65
delta BG (mg/dL)	-10.7	-8.1	-10.4	-19.4

# active engagements	<200	200 - 400	401 - 600	>600
delta BG (mg/dL)	-10.6	-19.4	-6.0	-13.5



C

Baseline A1C (%)	Second A1C (%)	Change in A1C (%)
8.9 +/-1.8	7.8+/-1.6	-1.1

P=0.0019 two-tailed P value, unpaired t test; n=49; mean time from activation of product to second A1C was 116 +/-74 days

In panel A, the mean BG entered in the first 2 weeks of usage was compared to the final two weeks of the third month of usage. As expected, more improvement was seen in mean BGs of users with higher baseline A1C. Insulin users and those over 65 had greater reductions. No clear relationship was identified between number of active engagements and change of BG. In panel B, reductions in BG extremes were noted in users of basal insulin but not in users of rapid-acting insulin. In panel C, there were significant reductions in self-reported A1C entries. Highs: BG>300 mg/dL; Lows: BG<70 mg/dL.

Conclusions

Using a systematic approach to evaluating patient-generated data delivers new knowledge for transforming care for patients. The usage metrics demonstrate a high degree of patient engagement which persists over time, is a function of age, provider-type, and complexity of the medication regimen. The outcomes metrics demonstrate improved glycemic outcomes. As mobile health products evolve, there will be growth in their potential for patient coaching and provider clinical decision support based on real-world data and not just the sparse information available at a patient visit.

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