Reimagining Diabetes Care: Leveraging Digital Health Technologies

William Hsu, MD
Current Diabetes Care Model
What’s Not to Like?
# Achievement of Goals in US Diabetes Care, 1999–2010

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Risk factors</strong></td>
<td></td>
<td></td>
<td></td>
<td>% of survey participants</td>
<td>percentage points</td>
</tr>
<tr>
<td>Glycated hemoglobin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;9.0%</td>
<td>18.4</td>
<td>13.0</td>
<td>12.6</td>
<td>−5.8 (−10.5 to −1.1)</td>
<td>−0.4 (−3.8 to 3.0)</td>
</tr>
<tr>
<td>&lt;8.0%</td>
<td>67.4</td>
<td>78.0</td>
<td>79.1</td>
<td>11.7 (6.3 to 17.1)</td>
<td>1.1 (−3.5 to 5.7)</td>
</tr>
<tr>
<td>&lt;7.0%</td>
<td>44.3</td>
<td>56.8</td>
<td>52.2</td>
<td>7.9 (0.8 to 15.0)</td>
<td>−4.6 (−11.1 to 1.9)</td>
</tr>
<tr>
<td>Blood pressure &lt;130/80 mm Hg</td>
<td>39.6</td>
<td>45.3</td>
<td>51.3</td>
<td>11.7 (5.7 to 17.7)</td>
<td>6.0 (0.4 to 11.6)</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>&lt;100 mg/dl</td>
<td>36.0</td>
<td>46.6</td>
<td>56.8</td>
<td>20.8 (11.6 to 30.0)</td>
<td>10.2 (2.5 to 17.9)</td>
</tr>
<tr>
<td>&lt;70 mg/dl for persons with CVD</td>
<td>15.9</td>
<td>23.2</td>
<td>27.5</td>
<td>11.6 (−4.1 to 27.3)</td>
<td>4.3 (−8.5 to 17.1)</td>
</tr>
<tr>
<td>Current smoker, self-reported or cotinine &gt;10 ng/ml</td>
<td>24.0</td>
<td>23.4</td>
<td>22.3</td>
<td>−1.7 (−6.2 to 2.8)</td>
<td>−1.1 (−5.4 to 3.2)</td>
</tr>
<tr>
<td>Glycated hemoglobin, blood-pressure, and LDL cholesterol targets and nonsmoking status achieved</td>
<td>4.6</td>
<td>9.5</td>
<td>14.3</td>
<td>9.7 (5.1 to 14.3)</td>
<td>4.8 (−0.4 to 10.0)</td>
</tr>
</tbody>
</table>

Disparities Across Ethnicity

Total Diabetes Prevalence
- White: 11%
- Black: 22%
- Asian: 21%
- Hispanic: 23%

Undiagnosed Diabetes
- White: 32%
- Black: 37%
- Asian: 51%
- Hispanic: 49%
THE COST OF DIABETES

Diabetes and pre-diabetes cost America $322 billion annually.

1 in 3 Medicare dollars & 1 in 5 healthcare dollars are spent caring for people living with diabetes in the U.S.
Back to the Patient

24 x 7 x 365
“It’s A Really Hard Job!”
Current Care Model Is A Direct Result of the Reimbursement Model
Health and Wellness Innovation 2013

Project Videos are Now Online

Projects
- CollaboRhythm
  Redefining healthcare delivery
- I'm Listening
  Giving patients the chance to speak
- Collective Discovery
  Discovering cures in 'everyday experiments'
- OoVi PT
  Making physical therapy fun and effective
- WeighMate
  Getting to know your food moods

People
- Frank Moss PhD
  Principal Investigator
- John Moore MD
  PhD Candidate
- Ian Esllick
  PhD Candidate
- Scott GIlroy
  Software Developer
- Mar Gonzalez Franco
  Visiting PhD Student

Recent Blog Posts
- Health and Wellness Innovation 2013 Covered in Fast Company
- Health and Wellness Innovation 2013 Awards
- Health and Wellness 2013 - 80 Amazing Participants - 6 Exciting Projects for Patient Empowerment
- GeckoCap, a Health and Wellness Innovation 2012 Spin-off, Is Gaining Momentum
- Moore Explores Apprenticeship as a Powerful New Paradigm of Chronic Disease Management
- Chameleon Wins Health and Wellness Innovation 2012
- Frank Moss in the Times - Consumer Health Can
Focus on Problem Area in Diabetes

Figure 1. Estimated Rates of Emergency Hospitalizations for Adverse Drug Events in Older U.S. Adults, 2007–2009.

Estimates were based on hospitalization data from the National Electronic Injury Surveillance System–Cooperative Adverse Drug Event Surveillance project for 2007 through 2009, and data for outpatient visits during which medications were ordered or continued are from the National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey for 2007 and 2008. High-risk medications are those designated as such in the elderly by the 2011 Healthcare Effectiveness Data and Information Set (HEDIS). 12 Potentially inappropriate medications are those identified by the updated 2002 Beers criteria for potentially inappropriate medication use in older adults. 13 All high-risk or potentially inappropriate medications were included in the analysis, regardless of the dose, frequency of use, formulation (e.g., short-acting), or duration of use. I bars denote 95% confidence intervals. For oral antplatelet agents, the coefficient of variation was greater than 30%.

Proof of Concept

- Develop a DM management program to support individuals with type 2 diabetes working with health coaches to initiate and titrate basal insulin, guided by the PREDICTIVE 303 algorithm and hypoglycemia treatment guidelines.
Rethinking Educational Model

- Approximately 5% of Medicare beneficiaries with newly diagnosed diabetes used DSMT services.
- 6.8% of privately insured, newly diagnosed adults participated in DSMT during the first year after diagnosis of diabetes.
Drag ‘N Cook

New Recipe
This is a new recipe. Drag foods into the cookware, then stir or shake to make it yours.

Cooking Directions
You can also provide step by step cooking directions for the recipe.

Nutrition Review

<table>
<thead>
<tr>
<th></th>
<th>AADI Guideline</th>
<th>Amount per Dish</th>
<th>Calories</th>
<th>Carbohydrate</th>
<th>Dietary Fiber</th>
<th>Sugars</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Portion: 2 1/8 cup (193 g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Portion: 1 x 0.25 cup (4 g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Portion: 39.7/8 x 3 oz (3389 g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>Known for its high nutritional Vitamin A, carrot is a root veg usually orange in color.</td>
<td>Portion: 1 cup (128 g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Cholesterol 2542 mg
Sodium 1916 mg
Potassium 11718 mg
Total Carbohydrate 25 g 1%
Dietary Fiber 9 g
Sugars 9 g
Protein 695 g 40%
Theoretical Framework

Cognitive Apprenticeship

Coach Articulates  
Patient Emulates  
Coach Fades and support

Enabled through Digital Technology Connectivity
Hypothesis

- Use of system with HCP helps individuals starting basal insulin achieve better glycemic control compared with standard clinical practice
Materials and Methods

- RCT, 12 ± 2 weeks
- Type 2 DM, ≥ 18 y.o. A1c 9-14%
- Decided to be on basal insulin by HCP
- Sees an educator to start insulin
- V1 – collect A1c, DTSQ, clinical data
- Randomization to tablet vs standard F/U
- Control received Joslin Care
Outcomes Analysis

■ Primary – A1c change in 3 months
■ Secondary - A1c <7%, patient satisfaction, hypoglycemia, time HCP and patients spent
■ Intention to treat analysis
Diabetes Management System

- Open source CollaboRhythm software, designed at MIT Media Lab
- Self-tracking tools, shared decision-making interfaces, streamlined communication tools, decision support tools for hypoglycemia
Interventional Group

- Trained on tablet
- Glucosemeter wirelessly connected to tablet
- QAM glucose check to determine night dose
- Use PREDICTIVE 303 as a guide
- No face to face appointment with HCP
- No change in non-insulin meds
- Start on 10-15 units and titrate up
- Dose adjustment communicated via tablet
Insulin Titration Decision Support

1. The average of your last 3 blood glucose measurements has been plotted with the diamond.
2. The recommended change in dose has been highlighted in orange. Keep in mind that the 303 Protocol is only a guide based on the average blood glucose. It does not account for diet, exercise, and other important factors.
3. The 303 protocol is only a guide. You can change your dose if there are factors that make it appropriate.
4. Click back if you do not want to make a change. Click Send to save your choice and send a message to your coach. Remember to check for feedback from your coach before using a new dose of insulin.

Learn more about insulin titration

- 156
- 110
- 80
- No Change
- No Change
- No Change
- No Change
- 3 Units
- -3 Units
- +2 Units
- +1 Units
- -1 Units
- -2 Units
- Send

Glyburide
Metformin hydrochloride
Insulin Glargine
Blood Glucose

Mon Tue Wed Thu Fri Sat Sun
Interventional Group Continued

- Initially daily communication, then fades
- Let patient decide on insulin doses over time
- No fax, call, face to face
- Instead use costumed interface, text message or real-time video and shared screen control
- Time spent, hypo, tracked electronically
Results

Total 40 subjects

20 Interventional
1 dropped out

20 Control
4 dropped out
Case Study #1

JK is a 54 y.o. woman
- 1 year history of DM
- BMI 21.3
- HbA1c 14.1%
- was started on repaglinide 1mg tid and glargine
Case Study #2

- 32 y.o. Caucasian male
- Type 2 DM, diagnosed 2007
- BMI 27
- HbA1c 9.2%
- On metformin 500mg in am and 1000mg in pm
Case Study #3

- 80 y.o. Caucasian woman
- Type 2 DM, diagnosed 2002
- BMI 42.8
- HbA1c - 12.1
- Started on glargine and glipizide 5mg bid
<table>
<thead>
<tr>
<th></th>
<th>Control group (n=20)</th>
<th>Intervention group (n=20)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>53.8</td>
<td>53.3</td>
<td>0.90</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>211.1</td>
<td>203.9</td>
<td>0.64</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>68.7</td>
<td>67.4</td>
<td>0.27</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>31.7</td>
<td>30.8</td>
<td>0.63</td>
</tr>
<tr>
<td>Years from diagnosis</td>
<td>9.0</td>
<td>9.6</td>
<td>0.79</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>10.9</td>
<td>10.8</td>
<td>0.92</td>
</tr>
<tr>
<td>Insulin dosage (units)</td>
<td>13.3</td>
<td>12.0</td>
<td>0.34</td>
</tr>
<tr>
<td>Non–insulin agents (n)</td>
<td>1.8</td>
<td>1.9</td>
<td>0.49</td>
</tr>
<tr>
<td>DTSQ score</td>
<td>34.3</td>
<td>31.9</td>
<td>0.41</td>
</tr>
</tbody>
</table>

DTSQ, Diabetes Treatment Satisfaction Questionnaire; HbA1c, hemoglobin A1c.
Additional Results

- Mean for first three glucose levels in month one vs month 3 (186.8 ± 56.5mg/dL vs. 141.5 ± 25.7mg/dL: P = 0.044)
- No significant changes (–0.48 pound in the intervention group vs. - 0.87 pound in the control group; P = 0.9)
- The final insulin dose was 24.6 ± 15.0 units (0.27 units/kg) in the intervention group and 21.9 ± 25.0 units (0.25 units/kg) in the control group (P = 0.69).
- Four subjects had hypo in Intervention vs two
Qualitative Results

- Feel less anxious and more motivated to get “back on track when I slip”
- “I am excited to see what it [glucose reading] is going to say each day.”
- “It’s comforting to know that they [clinician coaches] are always there.”
- “I like that it is convenient for me to communicate with my coach.”
- “It [communication with my coach] did not feel intrusive.”
Subjects felt empowered to make insulin adjustments collaboratively: “I enjoy the power sharing in making decisions on insulin doses.”

“I feel more equal with the coach in making decision about my health”

Subjects felt that they could now make the connection between their glucose reading and their behavior: “I am more conscious of what I eat now.” “I didn’t know that I felt bad before.” “I understand the reasons behind the decision (of changing insulin dose) much better.”
Complaints

- Subject complaints mainly focused on troubles connecting with the server via their tablet computers, highlighting the importance for a smooth connectivity in the technology design.
### Table 2. Interaction Time Between Healthcare Providers and Subjects During the Study Period

<table>
<thead>
<tr>
<th>Group</th>
<th>MD/ NP</th>
<th>CDE</th>
<th>Virtual visit time (min)</th>
<th>Mean messaging time (min)</th>
<th>Mean instruction time for using the app (min)</th>
<th>Mean phone time (min)</th>
<th>Total interaction time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Excluding app training</td>
</tr>
<tr>
<td>Intervention</td>
<td>NA</td>
<td>NA</td>
<td>22.5</td>
<td>43.4</td>
<td>40.0</td>
<td>NA</td>
<td>65.9</td>
</tr>
<tr>
<td>Control</td>
<td>20.0</td>
<td>48.8</td>
<td>N/A</td>
<td>NA</td>
<td>NA</td>
<td>12.8</td>
<td>81.6</td>
</tr>
</tbody>
</table>

*a* Time excluded the initial and exit visits.

*b* No significant difference measured.

App, application; CDE, certified diabetes educator; MD, medical doctor; NA, not applicable; NP, nurse practitioner.
Discussions
Acknowledgement

- BIDMC: Dr. Martin Abrahamson
- MIT Collaborators: John Moore, Scott Gilroy
- Harvard CT Chan School of Public Health: Ruyi Huang
- U Massachusetts Medical School: Hung Le