The widespread availability of mobile phones and new electronic disease management programs has opened potential new avenues to enhance self management of chronic disease. Diabetes Mellitus, with its complex treatment requirements, is a prime disease that could benefit from a mobile phone health (mHealth) strategy. To date there have been several small cell phone based diabetes studies using either text messaging or web-based “smart phones” with results showing reduction in HbA1c, hospitalizations, emergency room visits and increased achievement of diabetes standard of care goals. A meta-analysis of 22 diabetes mobile phone intervention trials reported a significant reduction of HbA1c (mean 0.5%) and enhanced self-management skills. Introducing cell phones with disease management applications has great potential to improve chronic care of diabetes, but the cell phone alone is not sufficient to make a difference. A successful mHealth home management health system requires attention to all of the many “links in the chain” of chronic care. This lecture will review the current status of mHealth applications for diabetes and the potential for the future.

References
4. Quinn, Charlene C. RN; PHD; Shardell, Michelle D. PHD; Terrin, Michael L. MD; MPH; Barr, Erik A. BA; Ballew, Shoshana H. BA; Gruber-Baldini, Ann L. PHD. Cluster-Randomized Trial of a Mobile Phone Personalized Behavioral Intervention for Blood Glucose Control. Diabetes Care 2011;34(9):1934–1942
Technology and Diabetes-
Mobile Medical Applications

Richard J Katz, M.D.
Professor of Medicine
Director, Division of Cardiology

Presenter Disclosure Information

In compliance with the accrediting board policies, the American Diabetes Association requires the following disclosure to the participants:
Richard J Katz, MD
Disclosed no conflict of interest.
Mobile Health (mHealth)
• Application of personal communication and information technology to healthcare
• mHealth platforms
  ➢ Cell phone: Text messaging
  ➢ Smart phone: “Apps”
  ➢ Dedicated devices
    ➢ Wireless internet connection
    ➢ Cell phone connection
    ➢ Periodic download

Mobile Health Applications
• Patient-centric
  ➢ Personal empowerment
  ➢ Health maintenance
• Function in real time with immediate feedback
• Problem-or disease-specific
  ➢ Personal record-keeping
  ➢ Coaching
  ➢ Education and self-care

Applications of mHealth
• Personal fitness
• Chronic diseases
  ➢ Asthma
  ➢ Diabetes
  ➢ Congestive heart failure
  ➢ Medication compliance
• Health education
  ➢ HIV/AIDS
  ➢ Smoking cessation
• International health issues
• Clinical data collection
  ➢ Photo images
  ➢ Laboratory modules
  ➢ Data transmission and display (EKG, X Ray, etc)
• Professional education and reference
### Potential Benefits of Integrated Mobile Health Systems

<table>
<thead>
<tr>
<th>Providers</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clinical decision support</td>
<td>• Improved treatment adherence</td>
</tr>
<tr>
<td>• Access to real time clinical data</td>
<td>• Frequent reinforcement of treatment goals</td>
</tr>
<tr>
<td>• Pattern analysis and recognition</td>
<td>• Improved patient understanding of the impact of behaviors on diabetes control</td>
</tr>
<tr>
<td>• Improved adherence to evidence-based guidelines</td>
<td>• Education resources</td>
</tr>
<tr>
<td></td>
<td>• Reminders</td>
</tr>
</tbody>
</table>

### Functions of Apps Relevant to Diabetes Prevention

<table>
<thead>
<tr>
<th>Education/information</th>
<th>Diary</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Health education</td>
<td>➢ Food consumption</td>
</tr>
<tr>
<td>➢ Database access (e.g., caloric content of foods)</td>
<td>➢ Exercise log</td>
</tr>
<tr>
<td>➢ Web access</td>
<td>➢ Personal images</td>
</tr>
<tr>
<td>➢ Training and coaching</td>
<td>➢ Data analysis and individualized feedback</td>
</tr>
<tr>
<td>➢ Exercise programs</td>
<td></td>
</tr>
<tr>
<td>➢ Meal planning</td>
<td></td>
</tr>
<tr>
<td>➢ Games</td>
<td></td>
</tr>
<tr>
<td>➢ Rewards</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Personal network (friends, family, etc)</td>
</tr>
<tr>
<td>➢ Community</td>
</tr>
<tr>
<td>➢ Coaches and providers</td>
</tr>
</tbody>
</table>

### mHealth Approaches

- **Unidirectional:**
  - Cell phone reminder to patient/care giver

- **Bidirectional:**
  - Patient/Cell phone ↔ Server ↔ Healthcare Team

- **Multidirectional:**
  - Patient/Cell Phone ↔ EMR ↔ Healthcare Team
    (MD, care manager, NP/PA, pharmacist, disease management service, hospital discharge team, community health worker)
Medication Reminders

• Automated reminder for medication refill
• Click to order and process – send or pickup
• Survey consumer mindset real time if declined

Automated Refill Request and Processing

• Automated reminder for medication refill
• Click to order and process – send or pickup
• Survey consumer mindset real time if declined

Pill Phone Study-Results
Pharmacy Refill Adherence

- 0.098
- 0.001

Baseline Pill Phone on Pill Phone off
What patients want from technology

- Real-time assistance with daily decision-making
- Ability to share information with healthcare team
- Connections with others for support

Chronic Disease Management
WellDoc mHealth Solution
Perfect! Your sugar is right where you aimed. The goal sugar for after breakfast is less than 180.
Effect of mobile phone intervention for diabetes on glycaemic control: a meta-analysis

Diabetes Control Center
Overview

If you want to add data or make any changes, hover over the icons. There's more to discover in the learning center. Check it out!

Legend:

Category | Source | Weight | Fixed/Random
---------|--------|--------|-------------

Effect of mobile phone intervention for diabetes on glycaemic control: a meta-analysis
Cluster-Randomized Trial of a Mobile Phone Personalized Behavioral Intervention for Blood Glucose Control

- 163 patients age 18-64 with DM2 HgA1c>7.5% in Primary Care Practice
- Randomize to 1) usual care, 2) coach only, 3) coach with PCP portal, 4) coach with PCP portal+decision support
  - Automated, real-time educational-behavioral messaging in response to cell phone glucose, meds, lifestyle behaviors
  - Diabetes educators "virtual" case managers supplement messages
- Primary outcome: HgA1c at 1 year

Quinn CC et al. Diabetes Care 2011;34:1934-42

Coach/portal/decision support: HgA1c 1.9%
Usual care: HgA1c 0.7%
Net HgA1c 1.2%, p<.001

Baseline HgA1c<9.0%
Baseline HgA1c>9.0%

GW/Chartered Family Health Center Cell Phone Project
GW/Chartered Health Diabetes Cell Phone Project

Hospitalizations/ER Visits
- Active Patients (#16) -

<table>
<thead>
<tr>
<th></th>
<th>Pre-study 12 months</th>
<th>On study 6-18 (mean 12 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitalizations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Patients</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>#Admissions</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>ER Visits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Patients</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>#Visits</td>
<td>21</td>
<td>1</td>
</tr>
</tbody>
</table>

GW/DC CCI Diabetes Cell Phone Project

Diabetes Care Measures: mean F/U 12 months

<table>
<thead>
<tr>
<th></th>
<th>Active Patients (#16)</th>
<th>Dropouts (#16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>Baseline: 68.8%</td>
<td>Study End: 100%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 37.5%</td>
<td>Study End: 18.8%</td>
</tr>
<tr>
<td>HgA1c</td>
<td>Baseline: 93.8%</td>
<td>Study End: 93.8%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 75%</td>
<td>Study End: 87.5%</td>
</tr>
<tr>
<td>Lipids</td>
<td>Baseline: 87.5%</td>
<td>Study End: 87.5%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 81.3%</td>
<td>Study End: 62.5%</td>
</tr>
<tr>
<td>Eye exam</td>
<td>Baseline: 56.3%</td>
<td>Study End: 18.8%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 62.5%</td>
<td>Study End: 25%</td>
</tr>
<tr>
<td>Foot exam</td>
<td>Baseline: 18.8%</td>
<td>Study End: 37.5%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 37.5%</td>
<td>Study End: 18.8%</td>
</tr>
<tr>
<td>Immunization</td>
<td>Baseline: 6.3%</td>
<td>Study End: 25%</td>
</tr>
<tr>
<td></td>
<td>Baseline: 12.5%</td>
<td>Study End: 18.8%</td>
</tr>
</tbody>
</table>

Patient Exit Questionnaire

<table>
<thead>
<tr>
<th>Feature</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program increased my glucose testing</td>
<td>100%</td>
</tr>
<tr>
<td>Instant feedback message helpful</td>
<td>100%</td>
</tr>
<tr>
<td>Phone glucose entry was a bother</td>
<td>6%</td>
</tr>
<tr>
<td>Case manager contact was helpful</td>
<td>88%</td>
</tr>
<tr>
<td>Messaging Case Manager was easy</td>
<td>41%</td>
</tr>
<tr>
<td>Would like daily reminder to test glucose</td>
<td>53%</td>
</tr>
<tr>
<td>Would like reminder to take meds</td>
<td>47%</td>
</tr>
<tr>
<td>Would like reminder for appointments</td>
<td>47%</td>
</tr>
<tr>
<td>Bring glucose diary to clinic</td>
<td>35% always 24% sometimes</td>
</tr>
<tr>
<td>Program helped other diabetes needs</td>
<td>65%</td>
</tr>
<tr>
<td>Worried about privacy</td>
<td>6%</td>
</tr>
</tbody>
</table>
GW/WellDoc Airforce Project
Integration of the WellDoc DiabetesManager® with the Allscripts EHR for patients and providers

VOXIVA: Care4life | Summary
Personalized program includes:
- Diabetes education and notification
- Glucose / Weight/ Exercise/ BP goals and logs
- Medication reminders/ adherence
- Appointment reminders
- Content:
  - Licensed from American Diabetes Association publication group
  - Aligned with ADA clinical guidelines
- Self-reported Outcomes:
  - 85% said Care4Life helped remember to take meds or attend doctor’s appointments
  - 88% said Care4Life helped set health goals
  - 84% said Care4Life improved knowledge of diabetes
  - 97% would recommend Care4Life to others
Care4life: Product Components

<table>
<thead>
<tr>
<th>Interactive SMS</th>
<th>Mobile Web</th>
<th>Mobile App</th>
<th>Personal Portal</th>
<th>Management Dashboard</th>
</tr>
</thead>
</table>

Targeted Outcomes
- Improved education (SDSCA - Summary of Diabetes Self-Care Activities Measure)
- Improved A1c
- Better appointment attendance (HEDIS)

User interface | Text msgs linked to mobile website
- Many text messages contain links to mobile web pages that provide the participant with more information on certain topics (sourced from ADA)

Wireless Blood Glucose Meter
- Display shows blood glucose level
- The meter connects to a smartphone for data synchronization.
**Sensors**

*Environment*
- Position
- Altitude
- Activity
- Light/dark
- Temperature

*Physiologic*
- Vital signs
  - pulse, blood pressure, temperature, respiratory rate
- Energy expenditure
- Sleep/wake
- Capillary or ECF glucose
- pO$_2$
- EKG

**Fitbit Activity Monitor**

- 22,500 steps taken
- 11 floors climbed
- 1.0 miles traveled
- 1,038 calories burned
- 197 active score
- Daily time standing: 20,598 steps
- Daily steps: 12,402
Zamzee is an online rewards program for young teens powered by their physical activity. To earn rewards, teens wear the Zamzee meter, a three-axis accelerometer specially calibrated to record short bursts of movement as well as vigorous activity. Physical activity recorded by the Zamzee meter powers a teen’s online account at Zamzee.com. Activity can be converted into spendable Zamz, a virtual currency used to purchase both online and tangible rewards.

Make Better Choices Trial

**Treatment Groups**

<table>
<thead>
<tr>
<th>Increase Fruits and Vegetables</th>
<th>Decrease Saturated Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase Physical Activity</td>
<td>✓</td>
</tr>
<tr>
<td>Decrease Sedentary Leisure</td>
<td>✓</td>
</tr>
</tbody>
</table>

Inclusion criterion: Presence of all four risk behaviors


**Interventions**

- Initial 3 week period of individualized “coaching” and email or telephone contact
- Handheld device:
  - “Thermometers” for diet and activity
  - Data logging
  - Monetary incentive for uploading data
  - Used exclusively after initial 3 weeks
SENSEI PERSONAL DIGITAL COACH

SENSEI DIABETES PLUS™

- Written in cooperation with the Joslin Clinic and the University of Miami Medical Center
- Based on the Diabetes Prevention Program
  - Healthy Nutrition Education & Meal Planning
  - Progressive Walking Program
  - Personalized Weight Loss
  - Tracking & Feedback of Glucose, Blood Pressure, Steps & Weight (Wireless Technology or self-reported)
  - Education & Self Management of Diabetes
Lifestyle choices account for the majority of healthcare costs - obesity, tobacco, cardiovascular disease, etc.

Sensei Wellness Plus™ is an engaging, integrated and comprehensive app to help individuals manage the most critical health related issues in America:

- Pre diabetes
- Metabolic Syndrome
- High Blood Pressure
- High Cholesterol
- Diabetes
- Obesity

Winner of a multimillion dollar grant to study research for pre-diabetes and diabetes prevention and treatment in Seniors

University of Miami & Miami VA

Winner of Health 2.0 Cardioengagement Challenge

"Create a game-changing way for patients to better manage their cardiovascular health" - Feb 2012

Delivers information in small bites,

(2) It is self-paced by the learner

(3) Provides immediate feedback, both positive and negative

Nutrition Program based on the DPP Curriculum Mobile Based Programmed Learning

SENSEI MOMENT™

Education & Self Management

(1) Delivers information in small bites,

(2) It is self-paced by the learner

(3) Provides immediate feedback, both positive and negative

SENSEI PREVENTION & WELLNESS

Reminders & Advice

Daily schedule is part of an automated alert and reminder system which may include personalized meal recommendations — healthy, appealing and portion controlled.
SENSEI INSPIRE™
Behavioral Marketing Promoting Better Behavior

- Provide high value promotions and rewards to encourage participation and outcomes
- Based on content, activity and goals - personalized, convenient and timely –
- Ad metrics and analytics are available
- Available on supported mobile phones
- Supports coupons, Bar codes (including 2D), Loyalty program, Click to call

ENGAGE, ENCOURAGE, ENJOY
Leverage the frenzy around local and national mobile coupons and promotions by targeting Health and Wellness Goals.

Set, Plan and Manage Goals
Receive Coupons and Promotions to help reach goals
Rewards (from paying advertisers) for reaching goals
Sensei's Integrated Contextual Ad Server delivers coupons and promotions directly to participants at each stage of the program.

Barriers to mHealth Technology
- Fear of loss of privacy
- Intrusiveness
- Cost
- Loss of interest over time
- Lack of human contact from healthcare team or social support networks