Digital Interventions: A Tour of Approaches and Evidence

Session 190, February 22, 2017
Robert Mittendorff MD MBA, Partner, Norwest Venture Partners
Speaker Introduction

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Partner
Norwest Venture Partners

Venture and growth equity investor and emergency physician focused on companies in the digital health, healthcare IT, healthcare services, and medical technology spaces.
Conflict of Interest

Robert Mittendorff MD MBA

Ownership Interest via Norwest Venture Partners in Health Catalyst, Omada Health, iRhythm, Telcare, CareCloud, ClearCare, TigerText, Crossover Health, iCardiac, AnalyticsMD, TalkSpace

The Views expressed herein are my own and are not attributable to any company investment or employer
Conflict of Interest

Robert Mittendorff MD MBA

Salary: yes
Royalty: no
Receipt of Intellectual Property Rights/Patent Holder: no
Consulting Fees (e.g., advisory boards): no
Fees for Non-CME Services Received Directly from a Commercial Interest or their Agents (e.g., speakers’ bureau): no
Contracted Research: no
Ownership Interest (stocks, stock options or other ownership interest excluding diversified mutual funds): yes through Norwest Venture Partners
Other: n/a
Agenda

• The Labor of Healthcare: Leverage, Automation, and AI
• Engagement and Persuasive Design: From Psychology to Digital Health
• Patient and Consumer Engagement Approaches in Digital Health
• Interventional Approaches in Outcomes
• State of the Evidence
• Summary
Learning Objectives

• Define the patient engagement models used in digital health interventions

• Define the business models associated with the aforementioned patient engagement models

• Describe the clinical protocols typically used in assessing the safety, efficacy, and cost effectiveness of digital health interventions

• Compare and evaluate the various interventional models, business approaches, and clinical protocols through a top level literature review of clinical data

• Justify the value of digital health interventions in improving labor leverage without compromising safety or efficacy
HIMSS Value Steps: How Benefits Were Realized for the Value of Health IT

Digital health interventions have the potential to produce:

1. Improve clinical outcomes
2. Increase patient satisfaction
3. Drive patient engagement
4. Reduce direct and indirect costs
"Do not be too timid and squeamish about your actions. All life is an experiment. The more experiments you make the better."

-- Ralph Waldo Emerson
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Labor is 50% of Healthcare Service Expense And Half of Admissions are Unscheduled (ED)

Share of Hospital Admissions by Source
50% = ER

Source: National Hospital Discharge Survey
Note: Totals exclude live births. Weighted counts with imputed values.

Percent of Hospital Operating Expenses By Source
49% = Salary

Technology and Labor Substitutes

From Dead Horses to the Model T

Source: Library of Congress website (top left and bottom left, Mittendorf analysis of auto registration data and horse and mule population in the US from 1900 to 1950)
Technology and Labor Substitutes

Pasteurization

Refrigeration in Home

Ice Man

Milk Man

State and Federal Laws

1971 FDA requires all milk transported interstate to be pasteurized;

...bye bye Milkman

Source: Library of Congress website
Technology and Labor Substitutes

EXHIBIT 1
Hospital Discharge Rates For U.S. Patients Age Forty-Five And Older With Coronary Artery Bypass Graft (CABG) And Percutaneous Coronary Intervention (PCI), 1990–2004

Discharges per 10,000 population

<table>
<thead>
<tr>
<th>Year</th>
<th>CABG</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990–92</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>1993–95</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>1996–98</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>1999–2001</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>2002–04</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Labor Centralization Leads to Scalability

Physician Employees

- 2014: 70%
- 2000: 30%

Source: Kaiser Family Foundation 2015 reports and NEJM Policy Center 2016
Using data, analytics, decision support, and predictive and prescriptive analytics to:

Treat or diagnose the patient by the right provider using the right test/treatment with the right equipment at the right time in the right setting in an efficient and cost effective way with the right followup and right monitoring using all of the data about that patient.
AI, ML, Deep Learning, and the Jargon

**Machine Learning (ML):** The use of algorithms to structure, parse, and learn from data sets (statistical or other) patterns that can be used to classify or predict in novel data sets.

- Supervised learning algorithms (training data is labeled)
- Unsupervised learning algorithms (training data is unlabeled)
- Semi supervised learning algorithms (training data is a mix of labelled and unlabeled)

(examples include Regularization /Elastic Net, Regression and Regression Trees, Nearest Neighbor, Decision Trees, Bayesian approaches, and 50+ more)

**Deep Learning (a ML technique):** The use of (frequently) neural networks (NN) trained on data sets to recognize patterns and features without an explicit parametric model. Neural networks can then be used on novel datasets to predict or classify.
Artificial Intelligence (AI): Engineering machines to think or mimic the thinking and operations of a human. Machine Learning is frequently considered a set of technologies found in an AI.

In Healthcare we like evidence to demonstrate capabilities on a “VALIDATION DATASET” that the system has never seen.
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If Chronic Dz is the Target, Behavior = Cause

**Figure 1.** Determinants of Health and Their Contribution to Premature Death.
Adapted from McGinnis et al.\(^\text{10}\)


**Figure 2.** Numbers of U.S. Deaths from Behavioral Causes, 2000.
Among the deaths from smoking, the horizontal bar indicates the approximately 200,000 people who had mental illness or a problem with substance abuse. Adapted from Mokdad et al.\(^\text{12}\)

The Digital Blockbuster is Behavior Change

Figure 1. Determinants of Health and Their Contribution to Premature Death.
Adapted from McGinnis et al.10


Figure 2. Numbers of U.S. Deaths from Behavioral Causes, 2000.
Among the deaths from smoking, the horizontal bar indicates the approximately 200,000 people who had mental illness or a problem with substance abuse. Adapted from Mokdad et al.12
Behavior Change Converts A to B

The Diabese Adult
$6,500 / Year

The “Healthy” Adult
$1,000 / Year

High Calorie Poorly Balanced Diet
Low Activity
Poor Medical “Compliance”

Calorie Appropriate Diet
Moderate Activity
Reasonable “Compliance”
In 1984, more than half of the world population lived in a country with less than 1 phone per 100 people, and two thirds had no access to a phone.

In 2014, global mobile phone penetration by country reached 96% and hit 90% in the developing world.

In 2014, more than 2 trillion text messages were sent in the US, and more than 8 trillion globally. (< 1 million in 1984)
Addicted to Candy Crush? Sweet. Here's Why
From Scaling to Replacing Labor with AI

AI and the Automation of Labor for Behavior Change

AI/ML & Predictive & Prescriptive Analytics in Real Time

Source: left, “Her” movie website, right, “Minority Report” movie website, all rights reserved to original publishers.
Artificial Intelligence Startups In Healthcare

Source: CBInsights 2016
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...there is **signal** and there is **noise**...
Proven Protocols & Persuasive Design

Source: YMCA (left) and king.com Candy Crush game (right)
Behavior modification can be more potent than a drug. 

Metformin

31%

8% of the population developed diabetes

NNT of 14

DPP (Behavior Alone)

58%

5% of the population developed diabetes

NNT of 6

DIGITAL THERAPY FOR BEHAVIOR CHANGE: AS GOOD AS A DRUG?

Omada Health
Prevent™ Program: The Birth of a Digital Therapeutic

Figure 1. Screenshot of Prevent’s online social network.
Evidence of Clinical Effectiveness

1- and 2-year results of single-arm study published in peer-reviewed journals

CDC DPRP Eligibility Criteria
1. Age 18+
2. BMI ≥ 24 kg/m²
3. Diagnosis of prediabetes
4. N = 220 (Enrolled);
   N = 187 (Analyzed at YR1 & YR2)

AVG HBA1C

- Diabetes Range: >6.4%
- Prediabetic Range: 5.7-6.4%
- Normal Range: 5.7%

-6.0%

5.6% 5.6%

AVG WEIGHT LOSS (%)

- YR1: -4.7%
- YR2: -4.2%

-5%

0% 5%
“...the rocket worked perfectly except for landing on the wrong planet...” (presumed) Wernher von Braun

Source: “Wernher von Braun - The Man Who Sold the Moon.”, et al.
Real Time Prescriptive Analytics Enables “Traffic Control” in Healthcare
Real Time Nudges Reduce LOS, Unnecessary Tests, and Left Without Being Seen Rates

- 30% LWBS
  - 850+ Families
- 14% LOS
  - 1,000,000 min
- 20% D2D
  - 732,000 min
- 40% Tests
  - $700,000

Source: AnalyticsMD data on actual customer deployments
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"Take calculated risks. That is quite different from being rash."

-- General George Patton
1. Clinical and operational improvements at the system level requires **digitization and structuring of data**

2. Once information is digitized, analytics professionals and a **culture of data driven improvement** must be created

3. Once an organization has the capability to organize around data, insight, and practice change, it must be continually rewarded for improving performance

<table>
<thead>
<tr>
<th>Business Models and Alignment with Interventional ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perpetual License</strong></td>
</tr>
<tr>
<td>(+) Aligns selling and implementation costs with revenue</td>
</tr>
<tr>
<td>(+) Can demonstrate rapid revenue ramp</td>
</tr>
<tr>
<td>(-) Lumpy and unpredictable sales</td>
</tr>
<tr>
<td>(-) Requires maintenance re-up annually</td>
</tr>
<tr>
<td><strong>Software as a Service and PMPM</strong></td>
</tr>
<tr>
<td>(+) Aligns use with revenues and cloud</td>
</tr>
<tr>
<td>(+) Aligns with user or patient onboarding</td>
</tr>
<tr>
<td>(-) Requires careful on boarding resourcing</td>
</tr>
<tr>
<td>(-) Requires more capital commitment into company</td>
</tr>
<tr>
<td><strong>Per Click or Per Procedure</strong></td>
</tr>
<tr>
<td>(+) Aligns use with revenues</td>
</tr>
<tr>
<td>(+) Rapid D2C on-boarding possible</td>
</tr>
<tr>
<td>(-) Requires conversion of customer each click unless “habit” results</td>
</tr>
<tr>
<td>(-) Requires training and implementation investment without known return for B2B2C</td>
</tr>
</tbody>
</table>
Significant Digital Health Research Is Being Performed in Randomized Interventional Approach

<table>
<thead>
<tr>
<th>Rank</th>
<th>Area</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SURGERY AND PROCEDURES</td>
<td>20%</td>
</tr>
<tr>
<td>2</td>
<td>OBESITY AND NUTRITION</td>
<td>19%</td>
</tr>
<tr>
<td>3</td>
<td>MENTAL HEALTH</td>
<td>11%</td>
</tr>
<tr>
<td>4</td>
<td>DEMENTIA</td>
<td>8%</td>
</tr>
<tr>
<td>5</td>
<td>PAIN</td>
<td>8%</td>
</tr>
<tr>
<td>6</td>
<td>PRE-DIABETES AND DIABETES</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>VACCINATION</td>
<td>5%</td>
</tr>
<tr>
<td>8</td>
<td>HEART DISEASE</td>
<td>4%</td>
</tr>
<tr>
<td>9</td>
<td>SMOKING</td>
<td>3%</td>
</tr>
<tr>
<td>10</td>
<td>ADHERENCE</td>
<td>3%</td>
</tr>
<tr>
<td>11</td>
<td>REHAB</td>
<td>3%</td>
</tr>
<tr>
<td>12</td>
<td>HIV AND HEPATITIS C</td>
<td>2%</td>
</tr>
<tr>
<td>13</td>
<td>PULMONARY</td>
<td>2%</td>
</tr>
<tr>
<td>14</td>
<td>CANCER</td>
<td>2%</td>
</tr>
<tr>
<td>15</td>
<td>ARTHRITIS</td>
<td>1%</td>
</tr>
<tr>
<td>16</td>
<td>STROKE</td>
<td>1%</td>
</tr>
<tr>
<td>17</td>
<td>PREGNANCY</td>
<td>1%</td>
</tr>
<tr>
<td>18</td>
<td>CONCUSSION</td>
<td>1%</td>
</tr>
<tr>
<td>19</td>
<td>EYE DISEASE</td>
<td>1%</td>
</tr>
<tr>
<td>20</td>
<td>HYPERTENSION</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Study Type**
- Interventional: 89%
- Observational: 11%

**Study Enrollment**
- Between 1 and 100: 38%
- Between 500 and 500: 35%
- Greater than 500: 28%

**Study Design**
- Randomized: 66%
- Non-Randomized / Other: 34%

Source: Analysis of 3,791 records of clinical trials at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) with "mobile OR app" in content
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The Evidence Pyramid: More is Better
And Even Nicer If Randomized and Controlled

Level 1: Systematic Reviews & Randomized Controlled Trials
Level 2: Cohort Studies
Level 3: Case-Controlled Studies
Level 4: Case Series
Level 5: Case Based Reasoning or Experts

More is Better
And Even Nicer If Randomized and Controlled
"Push" Reminders Work In Specific Settings

- 2002: The first text messaging study published in health (1); “Mobile phone text messaging can help young people manage asthma”
- 2014 Househ, et al.: First Meta-analysis of reviews (umbrella): 13 systematic reviews

"...low to moderate research evidence exists on the benefits of SMS interventions for appointment reminders, promoting health in developing countries and preventive healthcare…” - Househ, et al. 2014 (2)

- 2015: Hall, A. et al.: 15 systematic reviews of 89 unique studies ranging from [10-5,800 patients/study]

“Our review found that the majority of published text-messaging interventions were effective when addressing diabetes self-management, weight loss, physical activity, smoking cessation, and medication adherence for antiretroviral therapy” - Hall, A, et al. 2015 (3)

- 2015 Hall, A, et al 2015 Included Studies (abridged list of the 89):
  - Diabetes: 16 of 16 studies reported statistically significant effects on health outcomes or health behaviors (large variation in size & design)
  - Smoking Cessation: 6 of 8 studies demonstrating statistically significant behavior change or outcomes (smoking cessation, self report; 7 RCT)
  - Weight Loss/Physical Activity: 11 of 19 had statistically significant effects on weight and/or activity
  - Chronic Disease Management: 3 of 4 well designed studies from a group of 16 demonstrated statistical significance in outcome or behavior
  - Medication Adherence: 20 of 33 had statistically significant effects on behaviors or outcomes with asthma (3/3) and HIV (5/10)

IS TELEMEDICINE SAFE, EFFICACIOUS, AND DOES IT REDUCE COSTS?

- 2012 TeleICU Care: Systematic review of 865 citations with 11 observational studies that met selection criteria.

  "Telemedicine was associated with lower ICU & hospital mortality among critically ill patients." Wilcox, et al. 2012 (1)

- 2016 Telestroke: Systematic review and meta-analysis evaluating 529 records, with 7 studies involving 1,863 patients that met eligibility criteria.

  "Our findings indicated that … tPA delivery through telestroke networks is safe and effective in the 3 hour time window." Kepplinger, et al. 2016 (2)

- 2013 TeleBehavioral Health: 14 studies met inclusion criteria in comparing telehealth modality with nontelehealth (randomized) for depression.

  “Overall, we found no evidence to suggest that the delivery of psychotherapy via … telehealth…is less effective than nontelehealth means in reducing depression symptoms…” Osenbach, et al. 2013. (3)

- 2016 TeleUrgent Care: CalPERS TelaDoc study of first 19 months of experience; 1.3% of enrollees used service, 1 visit/yr avg.

  “Teladoc providers were less likely to order diagnostic testing and had poorer performance on appropriate prescribing for bronchitis…[and patients] were not preferentially located in underserved communities…” (4)
Clinical Decision Support Improves Care

- 2016 Clinical Decision Support in the ICU with (near) Real Time Data: 25 articles reviewed in meta-analysis of approaches of CDS in AIMS.


- 2012 Computerized Clinical Decision Support for Diabetes Management: 15 studies, with several at high risk of bias.

- 2012 Machine Learning and AI

  “Computerized clinical decision support systems in diabetes management may marginally improve clinical outcomes, but confidence in the evidence is low because of risk of bias, inconsistency and imprecision.”

First FDA Approval For Clinical Cloud-Based Deep Learning In Healthcare

K162513: “The Arterys Software is intended to be used to support qualified cardiologist, radiologist, or other ... practitioners for clinical decision-making...

Beckers tells me “This is a huge deal – it’s the first time this new way of imaging has been cleared for clinical application. It’s about truly helping clinical workflow to move into the cloud and deep learning and do something pretty substantial. It opens the seals, and sets a precedent for what can be done.”
Technology and Labor Substitutes

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Questions

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• Please complete online session evaluation