Digital Phenotyping

Tom Insel, MD
Co-founder and President, Mindstrong Health
May 15, 2019
What is the Problem We Need to Solve?
What is the Problem We Need to Solve?
No change in morbidity or mortality

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Neuropsychiatric Disorders</td>
<td>16.8</td>
<td>1</td>
</tr>
<tr>
<td>Cardiovascular and Circulatory Diseases</td>
<td>15.1</td>
<td>2</td>
</tr>
<tr>
<td>Neoplasms</td>
<td>11.8</td>
<td>3</td>
</tr>
<tr>
<td>Musculoskeletal Disorders</td>
<td>8.0</td>
<td>4</td>
</tr>
<tr>
<td>Diabetes, Urogenital, Blood, and Endocrine Diseases</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>Chronic Respiratory Diseases</td>
<td>5.1</td>
<td>6</td>
</tr>
<tr>
<td>Other Non-communicable Diseases</td>
<td>5.1</td>
<td>7</td>
</tr>
</tbody>
</table>

Percent of Total U.S. DALYs


https://www.cdc.gov/vitalsigns/suicide/index.html
Why have we failed to bend the curve?

- **Imprecise Dx**
  - Lack of biological validity

- **Lack of Engagement**
  - 60% not receiving care

- **Quality**
  - Fragmented, episodic, delayed

- **Lack of Measurement**
  - We don’t manage what we don’t measure
Why have we failed to bend the curve?

- Imprecise Dx: Lack of biological validity
- Lack of Engagement: 60% not receiving care
- Quality: Fragmented, episodic, delayed
- Lack of Measurement: We don’t manage what we don’t measure
MEASURING MOOD, COGNITION, AND BEHAVIOR

WHAT WE DO TODAY

• Subjective
• Episodic
• Clinic-based
• High burden
## MEASURING MOOD, COGNITION, AND BEHAVIOR

<table>
<thead>
<tr>
<th>WHAT WE DO TODAY</th>
<th>WHAT WE NEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Subjective</td>
<td>• Objective</td>
</tr>
<tr>
<td>• Episodic</td>
<td>• Continuous</td>
</tr>
<tr>
<td>• Clinic-based</td>
<td>• Ecological</td>
</tr>
<tr>
<td>• High burden</td>
<td>• Passive</td>
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</tbody>
</table>
Smartphones

A medical tool for global health – improving diagnosis and connecting care

Over 4 billion globally and 7 billion by 2024

Over 70 daily checks

Over 2600 daily “touches”

More ubiquitous than clean water, indoor plumbing, and stable electricity

DIGITAL PHENOTYPING
A New Kind of Biomarker

SENSORS
Activity
Location
Sociality

HCI - KEYBOARD
Reaction Time
Attention
Memory
Executive Function

VOICE/SPEECH
Prosody
Sentiment
Coherence
DIGITAL PHENOTYPING
A New Kind of Biomarker

Digital phenotype can also include “digital exhaust” (social media posts, search terms, AI personal assistants etc.)
DIGITAL PHENOTYPING
A New Kind of Biomarker

Digital phenotype can also include “digital exhaust” (social media posts, search terms, AI personal assistants etc.)
Volunteers \((n=27)\) compared on neurocognitive tests and digital biomarkers.

Correlations across multiple cognitive trait measures = .7 - .8 (roughly test–retest variance)

Dagum, Digital Medicine, 2018
I'm doing a lot better. I was experiencing a lot of auditory hallucinations. They made it difficult to sleep which made things progressively worse.

I checked myself into the hospital. They adjusted my medications, gave group therapy, and monitored me. I believe I slept for 12 hours each night 3 days in a row. What a relief! The hallucinations finally subsided.
tracking brain health in a 48 year old woman under care for bipolar disorder with psychosis
Ketamine: A Paradigm for Learning the Predictors of Recovery and Relapse

- Rapidly-acting antidepressant (6 hours)
- Frequent relapse (80% depressed again at 4 weeks)
- Multiple treatments over 6 months provide within-subject training for relapse and recovery
Digital Biomarkers and Affective States – Tracking Depression

Ketamine treatment of MDD (n = 10, 180 observations)

Overall correlation = 0.77, p = 2.9 x 10^{-36}

Source: Unpublished data Mindstrong and Kadima Clinic
<table>
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<td>Ecological</td>
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<tr>
<td>High Burden</td>
<td>Passive</td>
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</tbody>
</table>
The Digital Health Landscape

Not an App
But
An Operating System

Mobile Interventions

Learning Engine

Sensors
HCI
Voice
Sociality

Coordination
Data Capture
Quality Metrics
Feedback

CBT, DBT, IPT; Coaching; Peer Support; Crisis Intervention
# Mental Health Tech Landscape

## CCBT
- Headspace
- mindful
- joyable
- 10% Happier
- Big Health
- Sync Project
- Simple Habit
- Pacifica
- QuitGenius
- AKILI
- Inscap
- Happify
- moodpath
- CureApp

33% of companies analyzed / $5.8M avg funding amount

## Telepsychiatry
- BlueCall
- competencer
- Selfapy
- talkspace
- Able To
- LYRA
- Ginger.io
- reGroup
- iESO
- Workit Health
- Breakthrough
- IDOC WAY
- wecounsel

16% of companies analyzed / $6.7M avg funding amount

## Provider Tools
- Quartet
- inflexion
- CMHC Systems
- valant
- core solutions
- silvercloud
- mindstrong
- agile Health
- MINDCARE
- ValeraHealth

15% of companies analyzed / $5.7M avg funding amount

## Consumer Tools
- WEconnect
- webpsychology
- inquisithealth
- huddle
- connected health
- THRIVE GLOBAL
- find-circle
- Remente
- cafe page

13% of companies analyzed / $1.8M avg funding amount

## Hardware
- ybrain
- NEUROFLOW
- icarrot
- psious
- sana
- Limbix
- Kognito
- Woebot
- spring

12% of companies analyzed / $1.1M avg funding amount

## Applied AI
- meQuilibrium
- shine
- neurotrack
- Woebot
- spring
- kafka
- cognoa
- BigBeats
- Avalon
- bark

11% of companies analyzed / $3.8M avg funding amount
Digital Tools to Reduce Suicide

High Tech + High Touch

Predictive signals
- HCI data
- Speech/text signals
- Online classifiers

Crisis intervention
- Upskilling tools for volunteers
- On demand support
- Social networks

Postvention
- Care management
- Peer support
- AI nurse

High Tech + High Touch
The Digital Mental Health Challenge
Where Are We?

Value?
Does it work?

Improve real world outcomes
Adopted by patients and providers
Save time and money
The Digital Mental Health Challenge

ADOPTION OF DIGITAL HEALTH TOOLS
2015-2018

LEGEND

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIVE VIDEO</td>
<td>7%</td>
<td>22%</td>
<td>34%</td>
<td>33%</td>
</tr>
<tr>
<td>TELEMEDICINE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEARABLES</td>
<td>13%</td>
<td>24%</td>
<td>24%</td>
<td>28%</td>
</tr>
<tr>
<td>MOBILE</td>
<td>18%</td>
<td>22%</td>
<td>24%</td>
<td>28%</td>
</tr>
<tr>
<td>TRACKING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ONLINE</td>
<td>50%</td>
<td>58%</td>
<td>64%</td>
<td>71%</td>
</tr>
<tr>
<td>PROVIDER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVIEWS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ONLINE</td>
<td>79%</td>
<td>80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEALTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INFORMATION</td>
<td></td>
<td></td>
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</tbody>
</table>

Source: Rock Health Digital Health Consumer Adoption Survey (n2018 = 4,000; n2017 = 3,997; n2016 = 4,015; n2015 = 4,017)
The Digital Mental Health Challenge

**CONSUMER SENTIMENT ON DATA SHARING AND SECURITY**
*By entity, 2017-2018*

<table>
<thead>
<tr>
<th>Entity</th>
<th>Willingness to Share Health Data</th>
<th>Confidence in Data Security</th>
</tr>
</thead>
<tbody>
<tr>
<td>My Physician</td>
<td>72%</td>
<td>80%</td>
</tr>
<tr>
<td>My Health Insurance Company</td>
<td>49%</td>
<td>60%</td>
</tr>
<tr>
<td>My Pharmacy</td>
<td>47%</td>
<td>65%</td>
</tr>
<tr>
<td>Research Institution</td>
<td>35%</td>
<td>47%</td>
</tr>
<tr>
<td>Pharmaceutical Company</td>
<td>20%</td>
<td>39%</td>
</tr>
<tr>
<td>Government Organization</td>
<td>12%</td>
<td>31%</td>
</tr>
<tr>
<td>Tech Company</td>
<td>11%</td>
<td>31%</td>
</tr>
</tbody>
</table>

% of survey cohort reporting they are “Confident” or “Somewhat Confident” in the data security of entity.
The Digital Mental Health Challenge
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Trust?
Acceptance?

- Privacy – Surveillance?
- Agency – To me or By me?
- Data – Who? When? Where?
The Digital Mental Health Challenge

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Empowering Patients + Families with Information and Connection
Thank You!

Transforming Brain Health

tom@mindstronghealth.com