Bridging the Gap: Towards machine learning that matters in healthcare

Leo Anthony Celi MD MS MPH
MIT Institute for Medical Engineering & Science
Beth Israel Deaconess Medical Center,
Harvard Medical School

Disclosures

- No conflict of interest relevant to this presentation.
- Research funding from
  - National Institute of Health
  - Philips Healthcare
  - SAP
  - Amazon
  - Microsoft

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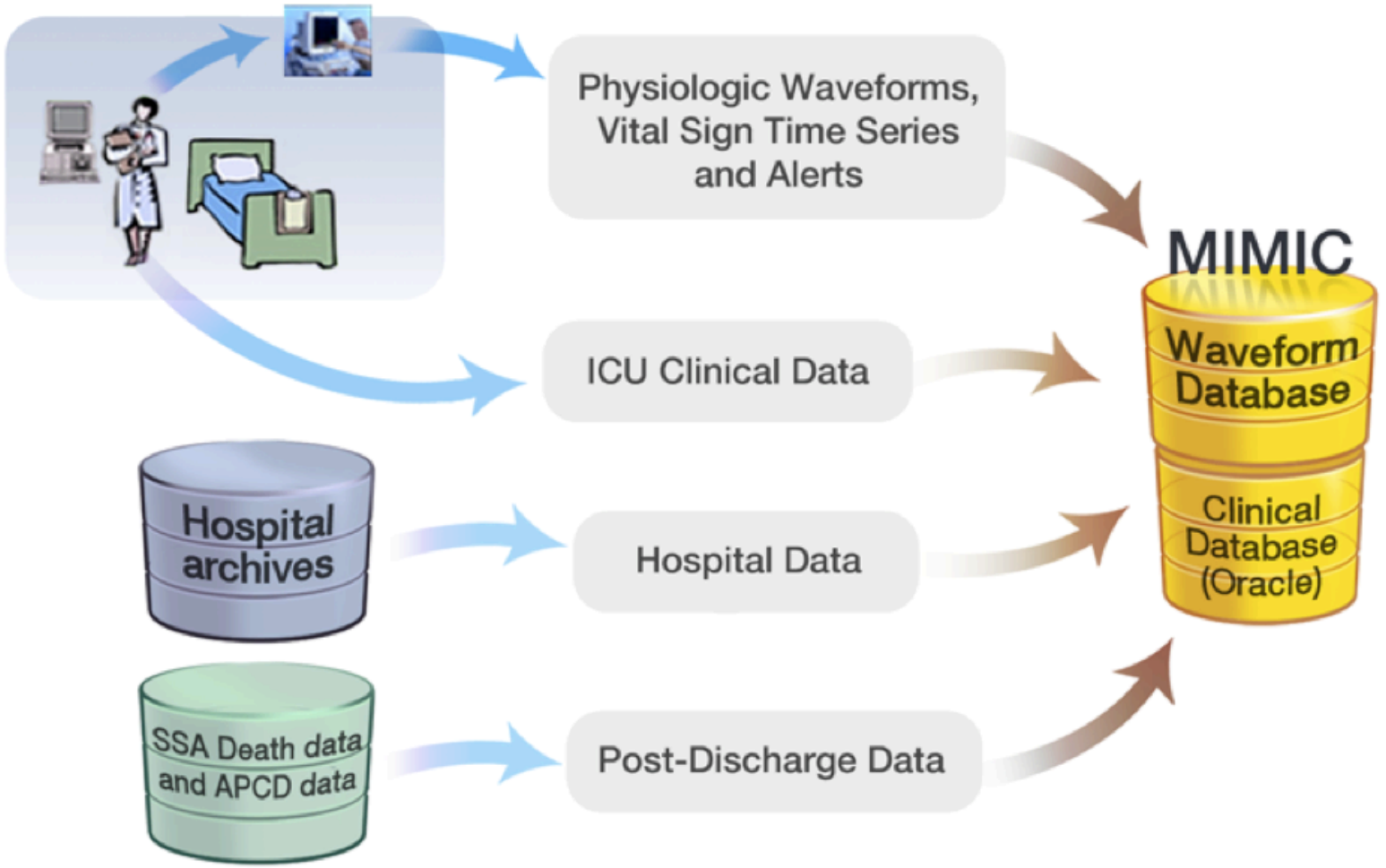
Sana

PhysioNet

Crowdsourcing Knowledge Discovery

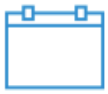
Medical Information Mart for Intensive Care



MIT Critical Data

NEWS ABOUT PAST EVENTS COURSE

Empowering Big Data in Critical Care



Transforming Critical Care

In many areas of science, government and business, analyzing very large amounts of information- Big Data- has become a major driver of innovation and success. In critical care, EHRs and collaborative approaches mean we are facing our own Data Revolution.

Meaningful Use of Big Data

Large amounts of data originating from critical care needs to be de-identified, analyzed and curated for it to be mined effectively. Clinicians and Data scientists must work together to understand and explore the meaningful, secondary use of Critical Care data.

Transforming Healthcare

Our vision is for the development of a care system consisting of Clinical Informatics without walls, in which the creation of evidence and clinical decision support tools in initiated, updated, honed and enhanced by scaling the access and meaningful use of Clinical Data.

criticaldata.mit.edu

Announcing Our Fall 2016 Critical Data Course

HST.953: Secondary Analysis of Health Data

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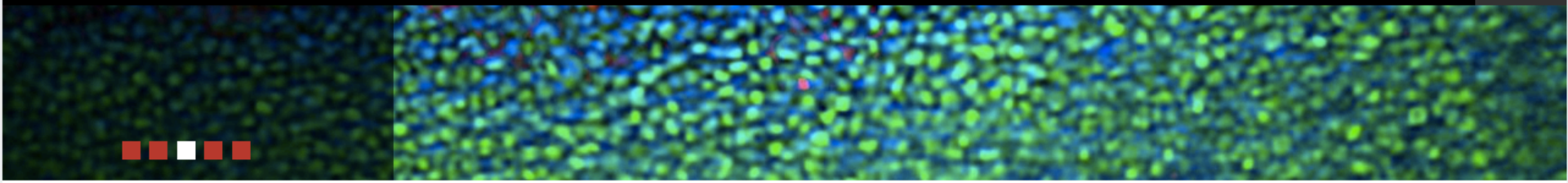
Secondary Analysis of Electronic Health Records

Authors: **MIT Critical Data**

Written with the aim of promoting an inter-disciplinary and ethical approach to health data analytics



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06 APRIL 2016
VOL 8, ISSUE 333

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SCIENCE TRANSLATIONAL MEDICINE | 06 APR 2016 : 333PS8 |

A "datathon" model combines complementary knowledge and skills to formulate inquiries and drive research that addresses information gaps faced by clinicians.

Abstract | Full Text | PDF

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Openly available database

eICU is a large multi-center ICU database made available by Philips Healthcare in partnership with the MIT Lab for Computational Physiology.


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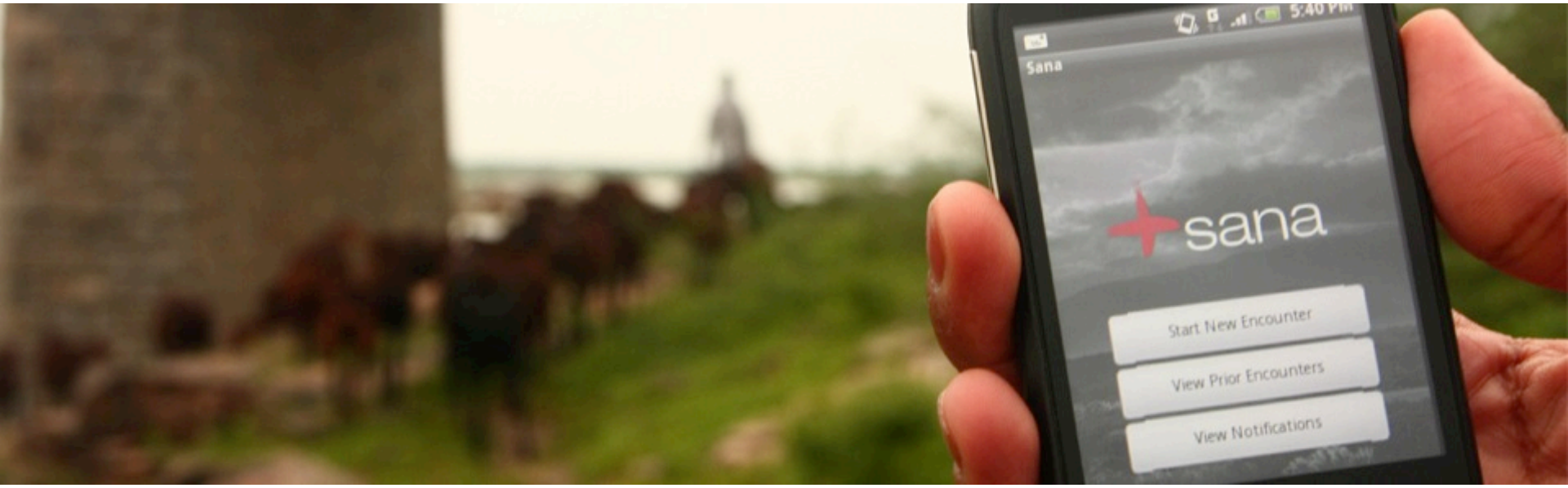
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View Prior Encounters
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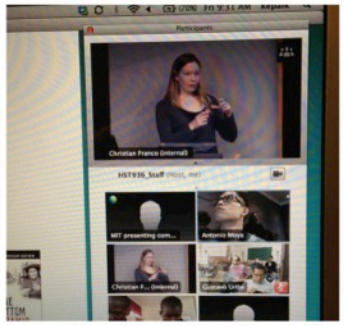
sana.mit.edu

HST.936: Global Health Informatics to Improve Quality of Care



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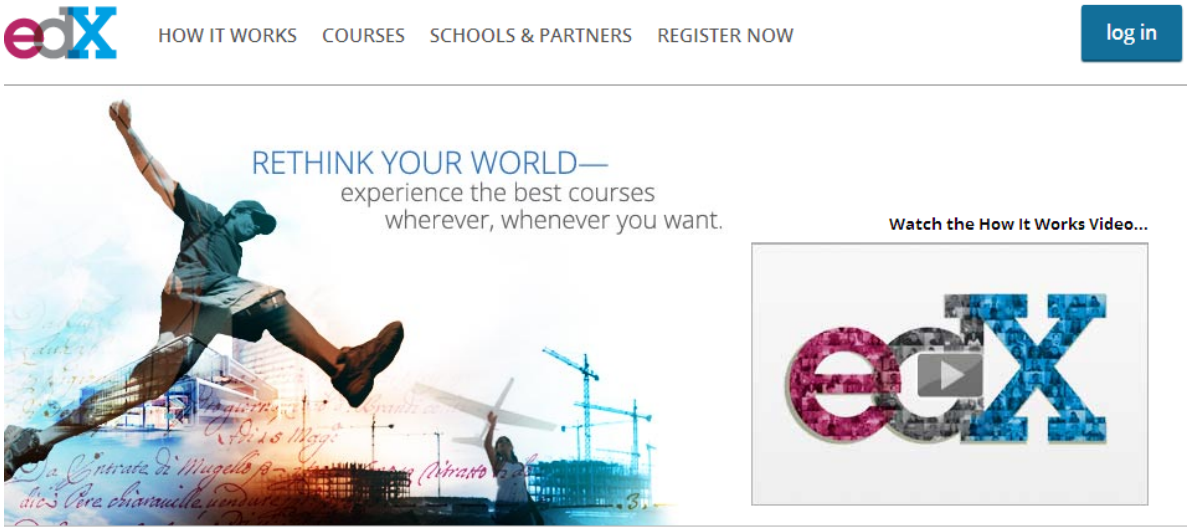

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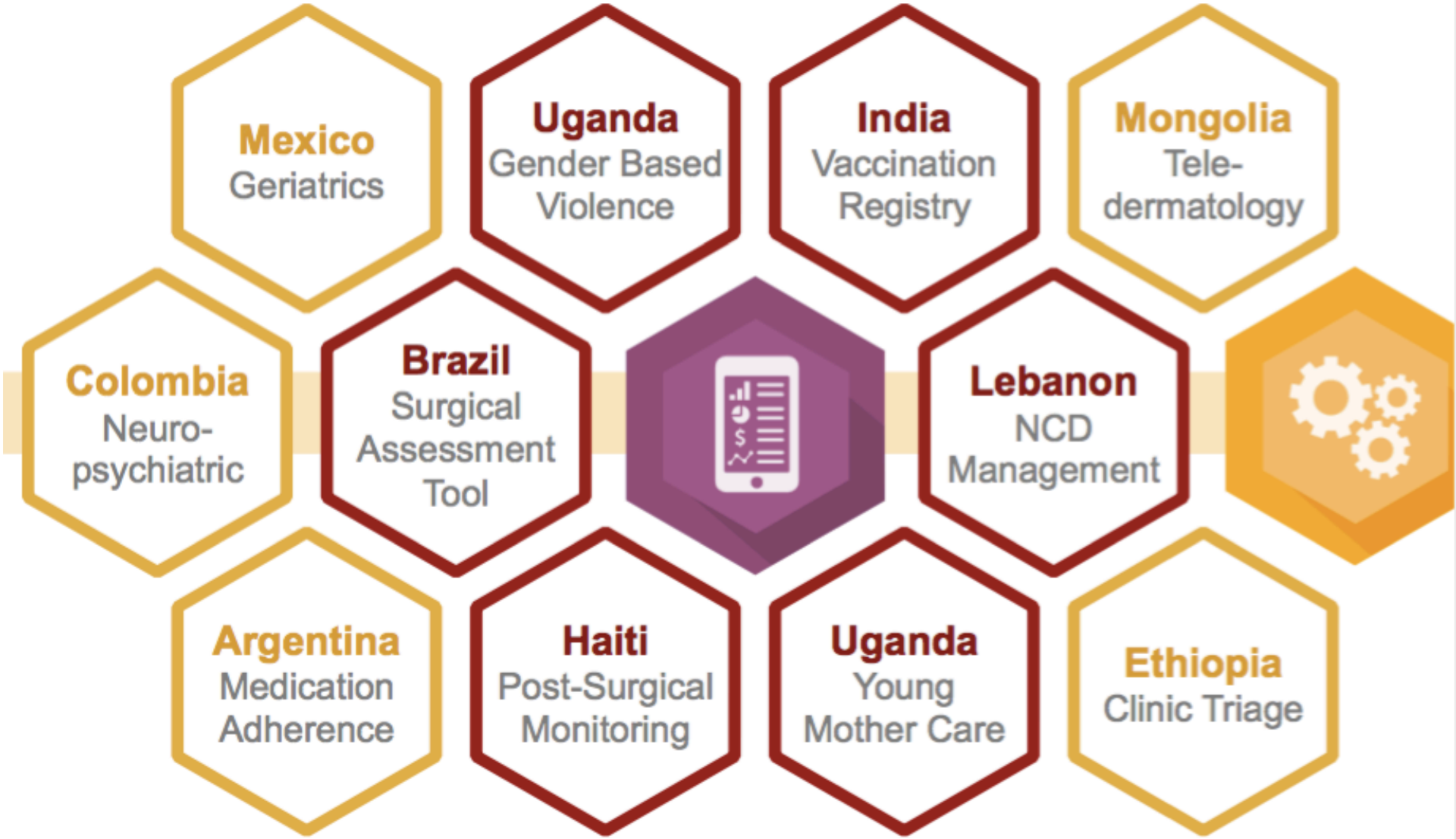
Global Health Informatics to Improve Quality of Care

Author's Name

MIT Press

PROJECTS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Uganda
Young Mother Care
Ethiopia
Clinic Triage

SundayReview | CONTRIBUTING OP-ED WRITER

Solving All the Wrong Problems

Allison Arieff JULY 9, 2016

Every day, innovative companies promise to make the world a better place. Are they succeeding?

Here is just a sampling of the products, apps and services that have come across my radar in the last few weeks:

A service that sends someone to fill your car with gas.

A service that sends a valet on a scooter to you, wherever you are, to park your car.

A service that will film anything you desire with a drone.

A service that will pack your suitcase — virtually.

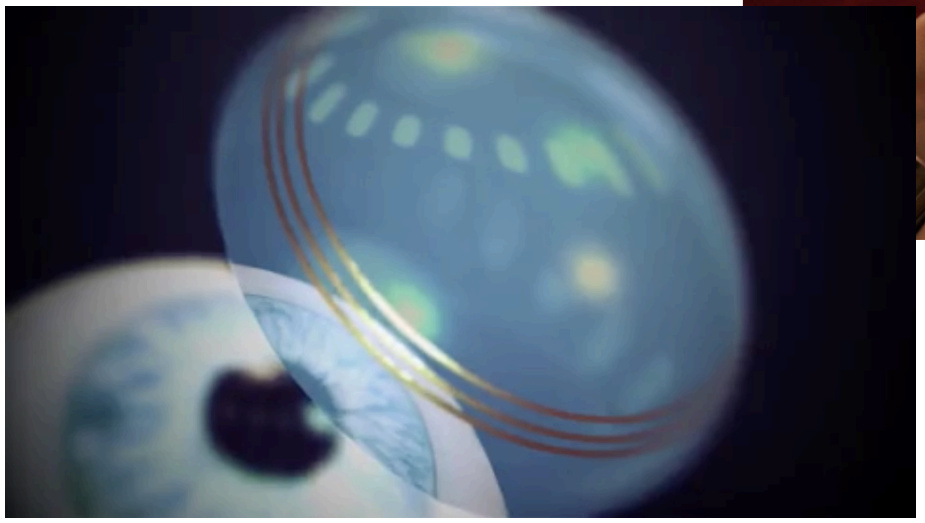
A service that delivers a new toothbrush head to your mailbox every three months.

A service that delivers your beer right to your door.

An app that analyzes the quality of your French kissing.

A "smart" button and zipper that alerts you if your fly is down.


IDEA: NANOPARTICLE CANCER
DETECTING WRISTBAND.

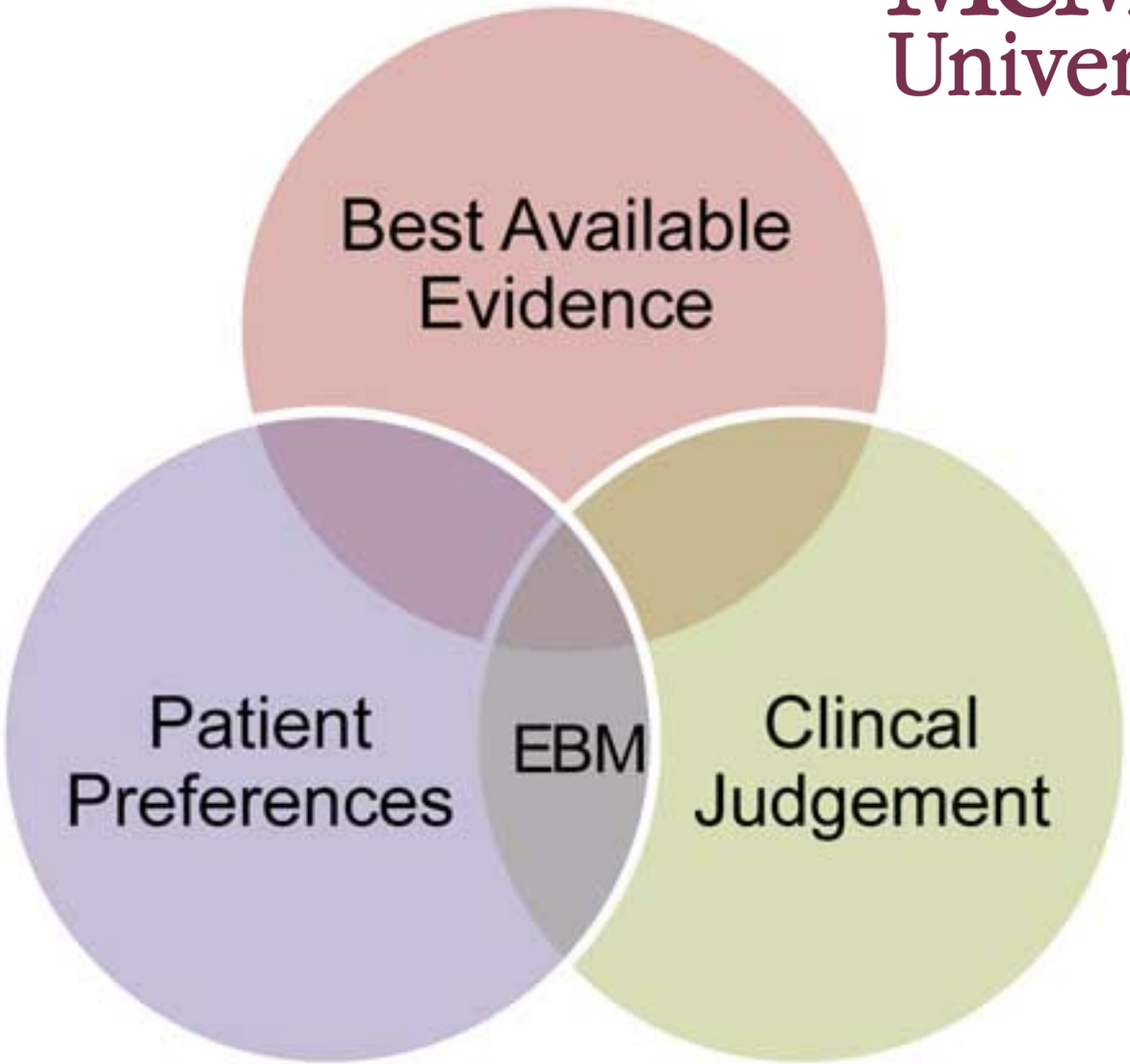


AHRQ
Advancing Excellence in Health Care

Established in 1989 in response to an Institute of Medicine report that pointed out

"**escalating healthcare costs, wide variations in medical practice patterns, and evidence that some health services are of little or no value**"

McMaster University



Evidence-Based Medicine

McMaster University

- Exercise caution in the interpretation of information derived from clinical experience and intuition, for it may at times be misleading
- The understanding of physiology and basic mechanisms of disease is necessary but insufficient guides for clinical practice.
- Understanding rules of evidence is necessary to correctly interpret literature on causation, prognosis, diagnostic tests, and treatment strategy.

How well is evidence-based medicine working?

PLOS | MEDICINE

RESEARCH ARTICLE

Financial Relationships between Organizations That Produce Clinical Practice Guidelines and the Biomedical Industry: A Cross-Sectional Study

Paul Campsall[1], Kate Colizza[2], Sharon Straus[3], Henry T. Stelfox[4,5,6,7,8]*

1 Department of Critical Care Medicine, University of Calgary, Calgary, Alberta, Canada, **2** Department of Medicine, University of Calgary, Calgary, Alberta, Canada, **3** Department of Medicine, Li Ka Shing Knowledge Institute, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada, **4** Department of Critical Care Medicine, University of Calgary, Calgary, Alberta, Canada, **5** Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada, **6** Department of Medicine, University of Calgary, Calgary, Alberta, Canada, **7** O'Brien Institute for Public Health, University of Calgary, Calgary, Alberta, Canada, **8** Alberta Health Services, Calgary, Alberta, Canada

Practice Guidelines and Conflict of Interest

- Majority of organizations (63%) that published clinical practice guidelines received funds from biomedical companies.
- Very few (1%) of the published clinical practice guidelines disclosed financial relationships.

Clinical Practice Guidelines We Can Trust

ISBN
978-0-309-16422-1

300 pages
6 x 9
PAPERBACK (2011)

Robin Graham, Michelle Mancher, Dianne Miller Wolman, Sheldon Greenfield, and Earl Steinberg, Editors; Committee on Standards for Developing Trustworthy Clinical Practice Guidelines; Institute of Medicine

- For many clinical domains, high-quality evidence is lacking, or even non-existent
- Often rely on low-quality evidence or expert opinion

Medical Pendulum

- Treatment or test considered beneficial one decade is deemed of no value or even harmful the next
- Examples:
  - Pulmonary artery catheterization in the intensive care unit
  - Estrogen replacement for women after menopause
  - Tight control of blood sugar among those with type 2 diabetes

Harrison's 1978
Management of Myocardial Infarction

- Rest in bed for 6 weeks
- Toilet use only after 2 weeks
- Avoid beta-blockers
- Lidocaine infusion to suppress ectopic beats
- No angiography (unstable plaque)

- Up to 98,000 die each year from preventable harm
- Based on 1984 data developed from reviews of medical records of patients treated in New York hospitals

JOURNAL OF PATIENT SAFETY

Journal of Patient Safety:
September 2013 - Volume 9 - Issue 3 - p 122–128
doi: 10.1097/PTS.0b013e3182948a69
Review Article

A New, Evidence-based Estimate of Patient Harms Associated with Hospital Care

James, John T. PhD

- An updated estimate is developed from modern studies published 2008-2011
- Number of premature deaths associated with preventable harm estimated at >400,000 per year

JAMA®
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VIEWPOINT

Toward a Safer Health Care System
The Critical Need to Improve Measurement

Ashish Jha, MD, MPH
Department of Health Policy and Management, Harvard T. H. Chan School of Public Health, Boston, Massachusetts.

Peter Pronovost, MD, PhD
Armstrong Institute for Patient Safety and Quality, Johns Hopkins Medicine, Baltimore, Maryland.

- Whether meaningful progress has occurred within patient safety is controversial.
- Biggest obstacle: measuring patient safety
- Current strategy uses administrative data with low validity (vs. clinical data)

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VIEWPOINT

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Department of Health Policy and Management, Harvard T. H. Chan School of Public Health, Boston, Massachusetts.

Peter Pronovost, MD, PhD
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- Causes of iatrogenic harm: ADE, nosocomial infections, diagnostic errors, surgical complications, VTE, decubitus ulcers, falls
- Validated, clinically based approach to measuring only 1 (nosocomial infections) of the 7

JAMA The Journal of the American Medical Association

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December 15, 2015, Vol 314, No. 23 >

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Viewpoint | December 15, 2015

Measurement Is Essential for Improving Diagnosis and Reducing Diagnostic Error

A Report From the Institute of Medicine

Elizabeth A. McGlynn, PhD[1]; Kathryn M. McDonald, MM[2,3]; Christine K. Cassel, MD[4]

The average US patient can expect to be harmed by a diagnostic error at some point.

Table. Common Causes of Hospital Adverse Events and Potential Measures and Data Sources

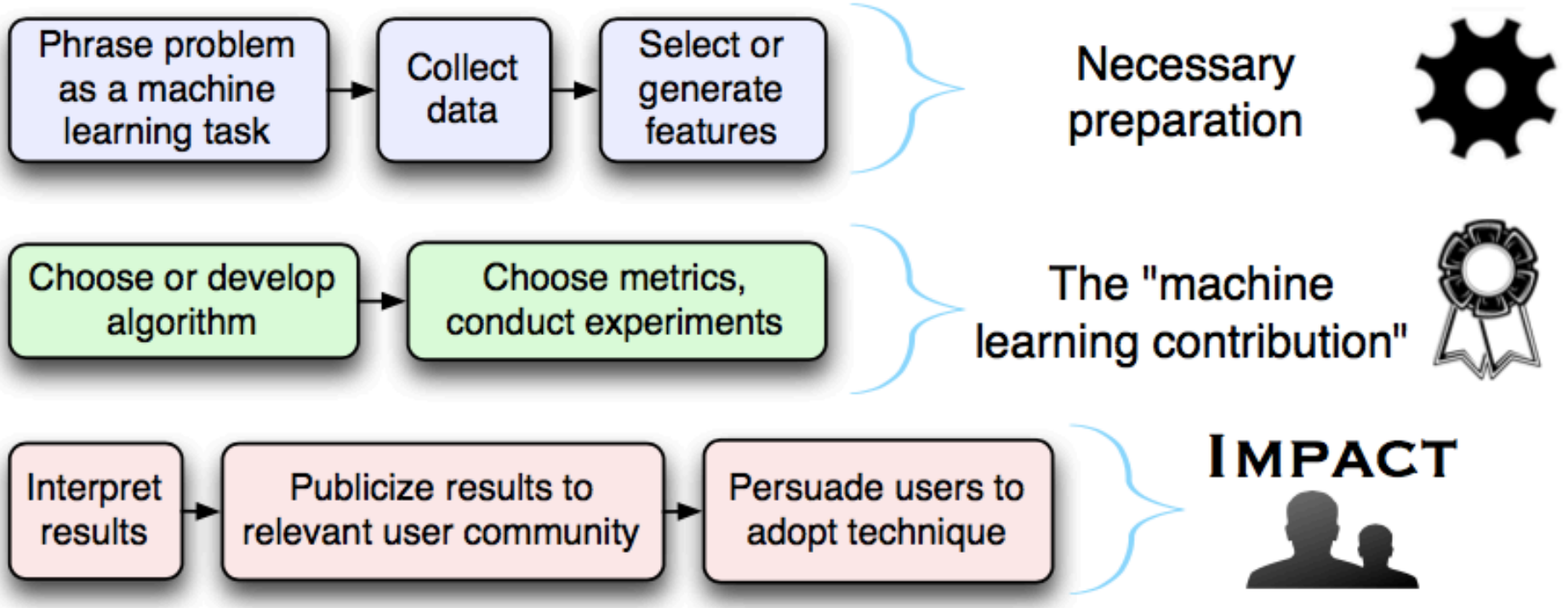
Events	Potential Measures	Data Sources From Electronic Health Records
Adverse drug events	Allergic reactions, elevated blood creatinine following nephrotoxin prescription, prescription of antidotes (eg, naloxone)	Order entry, laboratory results, clinical notes for confirmation
Deep vein thrombosis (DVT)	Rate of postoperative DVT, rate of pulmonary embolism, laboratory abnormalities (eg, elevated D-dimer)	Radiology reports, laboratory results, clinical notes for confirmation
Falls	Rate of falls among older patients	Nursing notes, clinical notes, radiology reports
Decubitus ulcers	Rate of decubitus ulcers	Nursing notes, physician notes, nurse-completed single-question ulcer assessment
Nosocomial pneumonia	Rate of nosocomial pneumonia	Nursing notes, laboratory results, radiology reports
Diagnostic errors	Rate of missed diagnosis of acute myocardial infarction	Clinical notes, electrocardiogram, laboratory results

- Harness clinical data from EHR to develop algorithms for detecting the other leading causes of preventable harm

Machine Learning that Matters

Kiri L. Wagstaff KIRI.L.WAGSTAFF@JPL.NASA.GOV
Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 USA

- Proliferation of ML papers that evaluate algorithms on isolated benchmark datasets
- Results rarely communicated back to the origin of the dataset: no emphasis on connecting ML advances to the real world
- Improvements in performance rarely accompanied by an assessment of whether those gains matter to the world outside of ML research


Phrase problem as a machine learning task
Collect data
Select or generate features
Necessary preparation
Choose or develop algorithm
Choose metrics, conduct experiments
The "machine learning contribution"
Interpret results
Publicize results to relevant user community
Persuade users to adopt technique
IMPACT

Area under the ROC

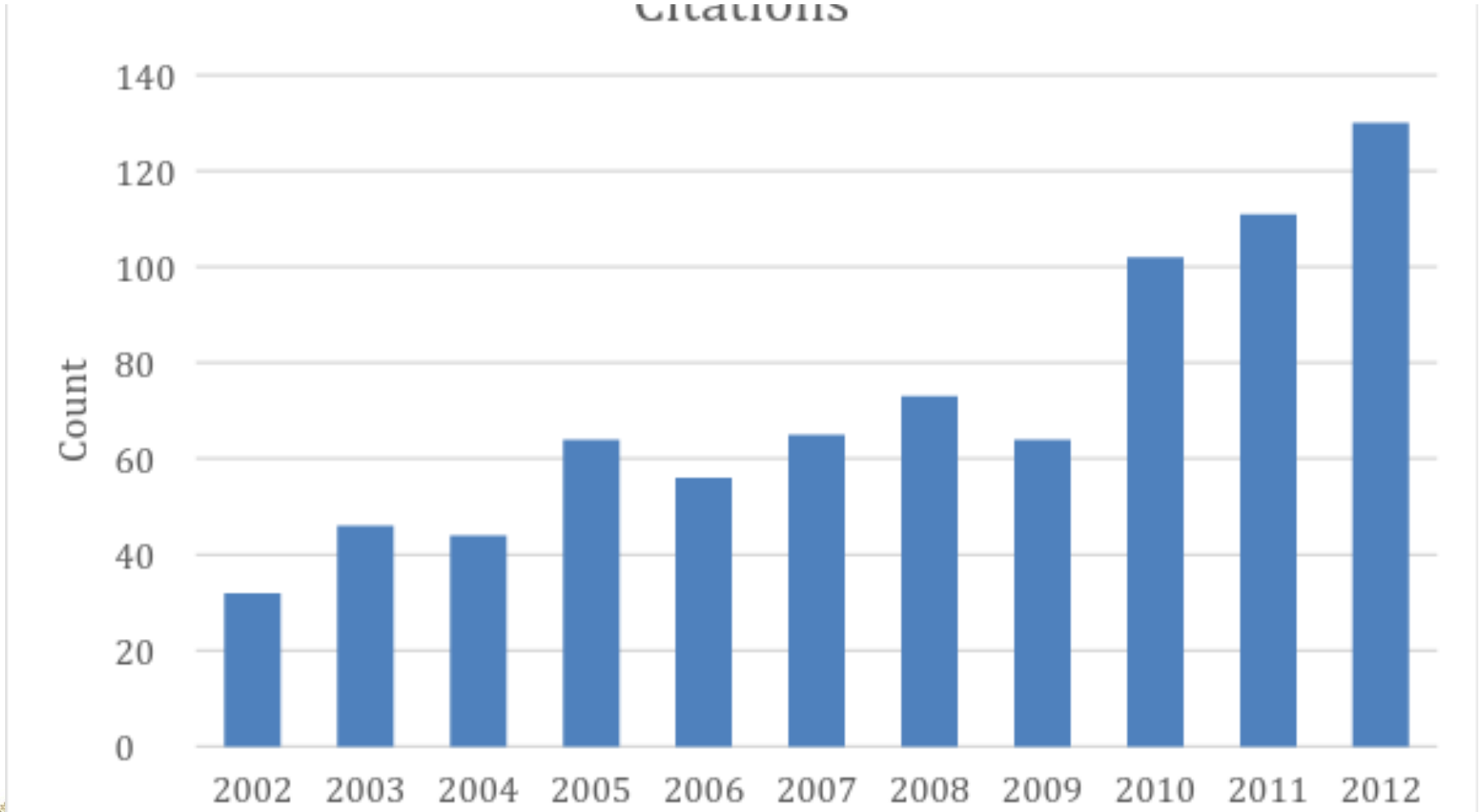
- Summarizes performance over all possible regimes even if they are unlikely ever to be used (e.g. extremely high false positive rates)
- Weights false positives and false negatives equally, which may be inappropriate for a given problem domain
- Insufficiently grounded to meaningfully measure impact

Machine Learning that Matters

Kiri L. Wagstaff KIRI.L.WAGSTAFF@JPL.NASA.GOV
Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109 USA

"It is easy to run an algorithm on a dataset you downloaded. It is very hard to identify a problem for which ML may offer a solution, determine what data should be collected, select or extract relevant features, choose an appropriate learning method, select an evaluation method, interpret the results, publicize the results to the relevant community, persuade users to adopt the technique, and (only then) to truly have made a difference."

Predictive Algorithms in Sepsis



The NEW ENGLAND JOURNAL of MEDICINE

Accelerating Innovation in Health IT

Robert S. Rudin, Ph.D., David W. Bates, M.D., and Calum MacRae, M.B., Ch.B., Ph.D.

The Divide between Health IT Developers and the Users (Clinicians and Patients)

Divide between Health IT Developers and Users

- Health IT developers in IT companies, start-ups, or academic research departments have little to no contact with patients and clinicians and often lack a deep understanding of users' needs.
- Startups: developers are young and healthy, with little firsthand knowledge of clinicians or the chronically ill patients who consume most health care services.

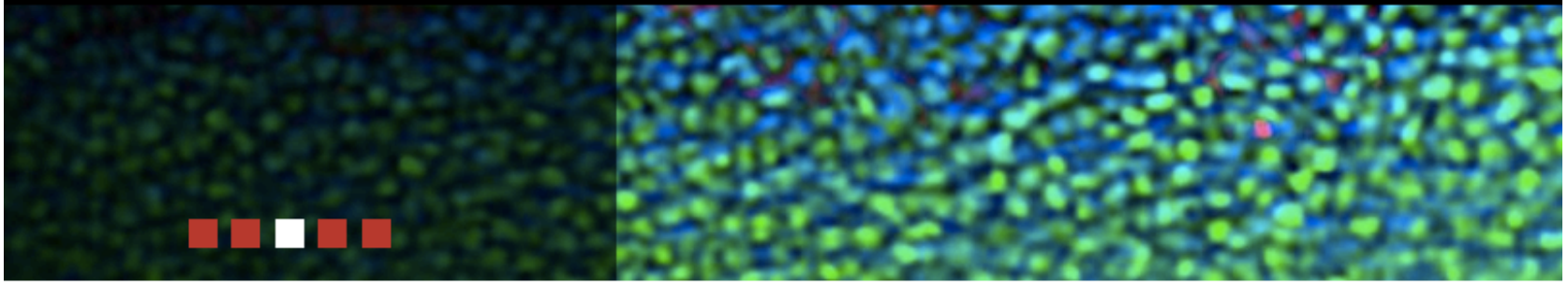
Divide between Health IT Developers and Users

- Venture capital clustered in wellness companies making products such as fitness trackers that cannot help the patients most in need and thus will have little effect on health care costs
- Some startups target clinicians and chronically ill patients, but generally underestimate the effort needed to understand such complex and diverse users.

Divide between Health IT Developers and Users

- Tools built on the basis of fundamental misconceptions about clinical utility of new data sources (e.g., episodic blood pressure and glucose readings, accelerometry)
- Incorrect design assumptions about when and how clinicians are available to respond to data produced by monitoring devices and when such contact is appropriate and clinically useful

Breaking Down the Silos



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A "datathon" model combines complementary knowledge and skills to formulate inquiries and drive research that addresses information gaps faced by clinicians.

Abstract | Full Text | PDF

Published in final edited form as:
Harv Med Stud Rev. 2015 January ; 2(1): 24–27.

Preparing a New Generation of Clinicians for the Era of Big Data

Ari Moskowitz, MD[1], **Jakob McSparron, MD**[1], **David J. Stone, MD**[3], and **Leo Anthony Celi, MD, MPH, MS**[1,2,*]

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Accelerating Innovation in Health IT

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- Few are trained to specify ideas in a way that can be turned into workable software or understand IT capabilities well enough to propose technically feasible approaches.
- Experienced clinicians may have difficulty imagining how their workflows may be altered or processes re-engineered.

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Preparing a New Generation of Clinicians for the Era of Big Data

Ari Moskowitz, MD[1], Jakob McSparron, MD[1], David J. Stone, MD[3], and Leo Anthony Celi, MD, MPH, MS[1,2,*]

Creating a medical culture that is aware of and respectful of the importance and potential power of data for supporting and improving both practice and research may be the most important and ultimately effective element.

Published in final edited form as:
Harv Med Stud Rev. 2015 January ; 2(1): 24–27.

Preparing a New Generation of Clinicians for the Era of Big Data

Ari Moskowitz, MD[1], Jakob McSparron, MD[1], David J. Stone, MD[3], and Leo Anthony Celi, MD, MPH, MS[1,2,*]

Making a prolific researcher requires instilling healthy skepticism and critical thinking skills, and understanding what evidence-based medicine truly means.

Institutional Support for Collaboration

>300 people with backgrounds across hardware design, big data computing, and gene sequencing linked with disease centers within Mount Sinai Health System

Institutional Support for Collaboration

US Department of Veterans Affairs
Big Data Scientist Training
Enhancement Program

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Accelerating Innovation in Health IT

Robert S. Rudin, Ph.D., David W. Bates, M.D., and Calum MacRae, M.B., Ch.B., Ph.D.

- Developing a thorough understanding of needs through direct interaction with users
- Most organizations underinvest in this critical activity!

MIT | PHILIPS Research Award for Clinicians

Program information | Faculty Information | Clinician Information | Contact

Funding Announcement

The **MIT-Philips Research Awards for Clinicians Program** is designed to recruit frontline clinicians - physicians, pharmacists, nurses, respiratory and other therapists - to engage in collaborative research with MIT and Philips investigators. The program will provide an opportunity for clinical professionals to conduct original research in collaboration with experienced MIT and Philips Research investigators. It is intended to further engage the clinical community with the MIT-Philips collaboration and to accelerate the discovery of new ideas with high translational potential.

The program will provide to clinicians:

1. An opportunity to build collaborative relationships with MIT faculty and Philips Research investigators.
2. Salary support of $50,000 (plus associated MIT indirect costs) to cover 50% of the clinician's time for research.
3. The opportunity to advance great ideas from the clinical setting to the research development laboratories of two world renowned centers of discovery.

The program will provide to MIT faculty members:

1. A funded part-time clinician to collaborate on a research project of mutual interest.
2. An opportunity to collaborate with a researcher at Philips Research of North America, including the possibility of developing joint proposals for funding under the MIT-Philips Research Alliance.

The NEW ENGLAND JOURNAL of MEDICINE

Accelerating Innovation in Health IT

Robert S. Rudin, Ph.D., David W. Bates, M.D., and Calum MacRae, M.B., Ch.B., Ph.D.

- IT benefits from other industries do not result from "paving the cow path."
- Major transformations occur after intensive process reengineering.
- Changes will require not just knowledge of current user needs, but the imagination to address needs that users haven't even yet considered.

Solving the Wrong Problems?

"Physicians use diagnostics less than optimally, but it is not clear that healthy people or patients can be trained to use diagnostics more wisely."

- John Ioannidis

- The notion of patients and healthy people being repeatedly tested sounds revolutionary.
- But even if tests were accurate, when performed in massive scale and multiple times, over-diagnosis and overtreatment will increase, as errors accumulate with multiple testing.

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