Personalized and Computational Cardiology

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Yale SCHOOL OF MEDICINE

@hmkyale

Relevant Disclosures

- Harlan M. Krumholz is co-founder of HugoHealth and RefactorHealth. I am an advisor to FPrime.
- I am biased toward questioning the wisdom of the way we usually do things.

Yale University

CENTER FOR OUTCOMES RESEARCH & EVALUATION

Outcomes research seeks to study and optimize healthcare results for the benefit of patients and society. We strive to investigate, learn and optimize. The goal is to create knowledge and apply it in the service of producing better health outcomes.
We are results oriented.

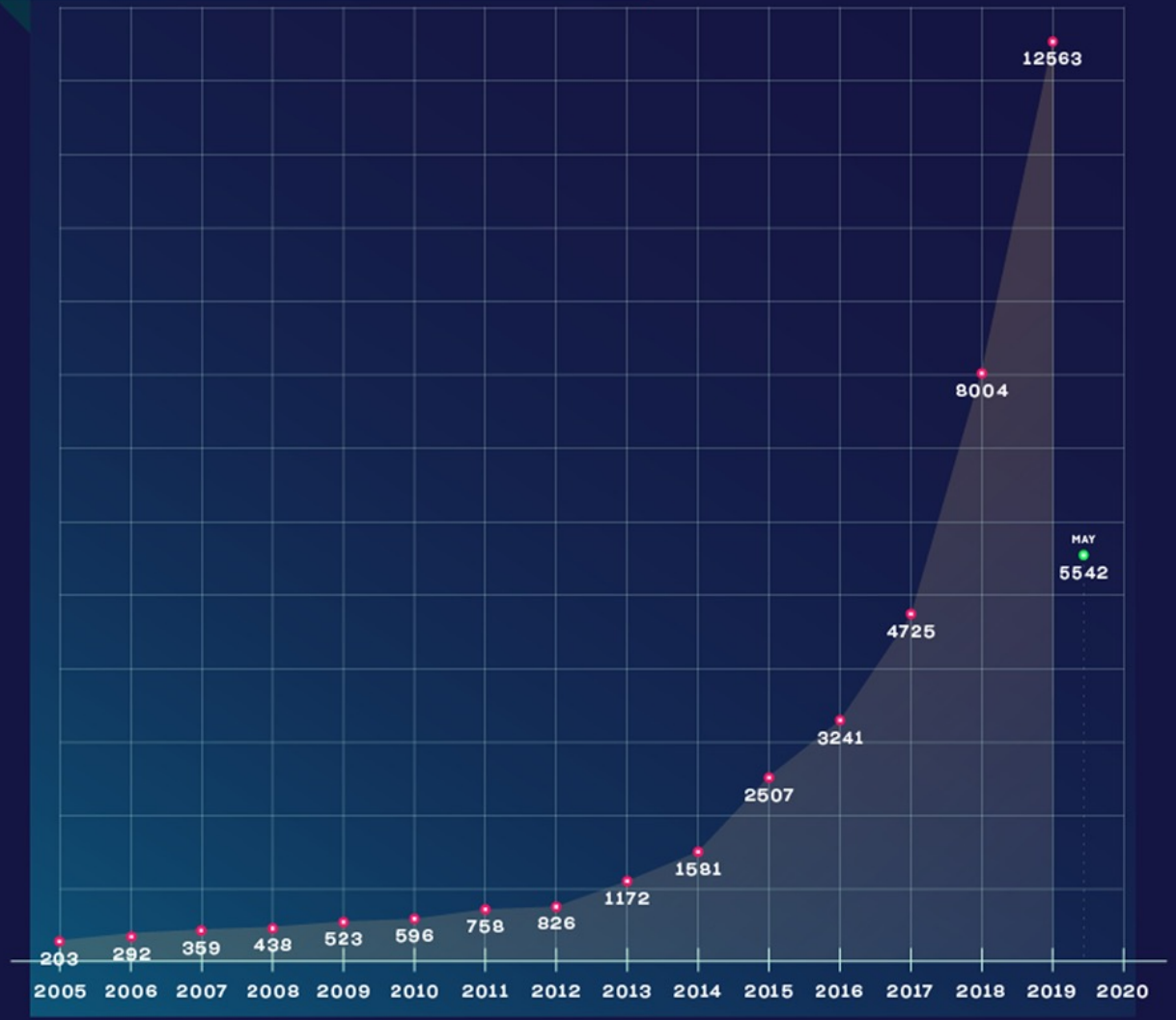
Medicine is becoming an information science.

a

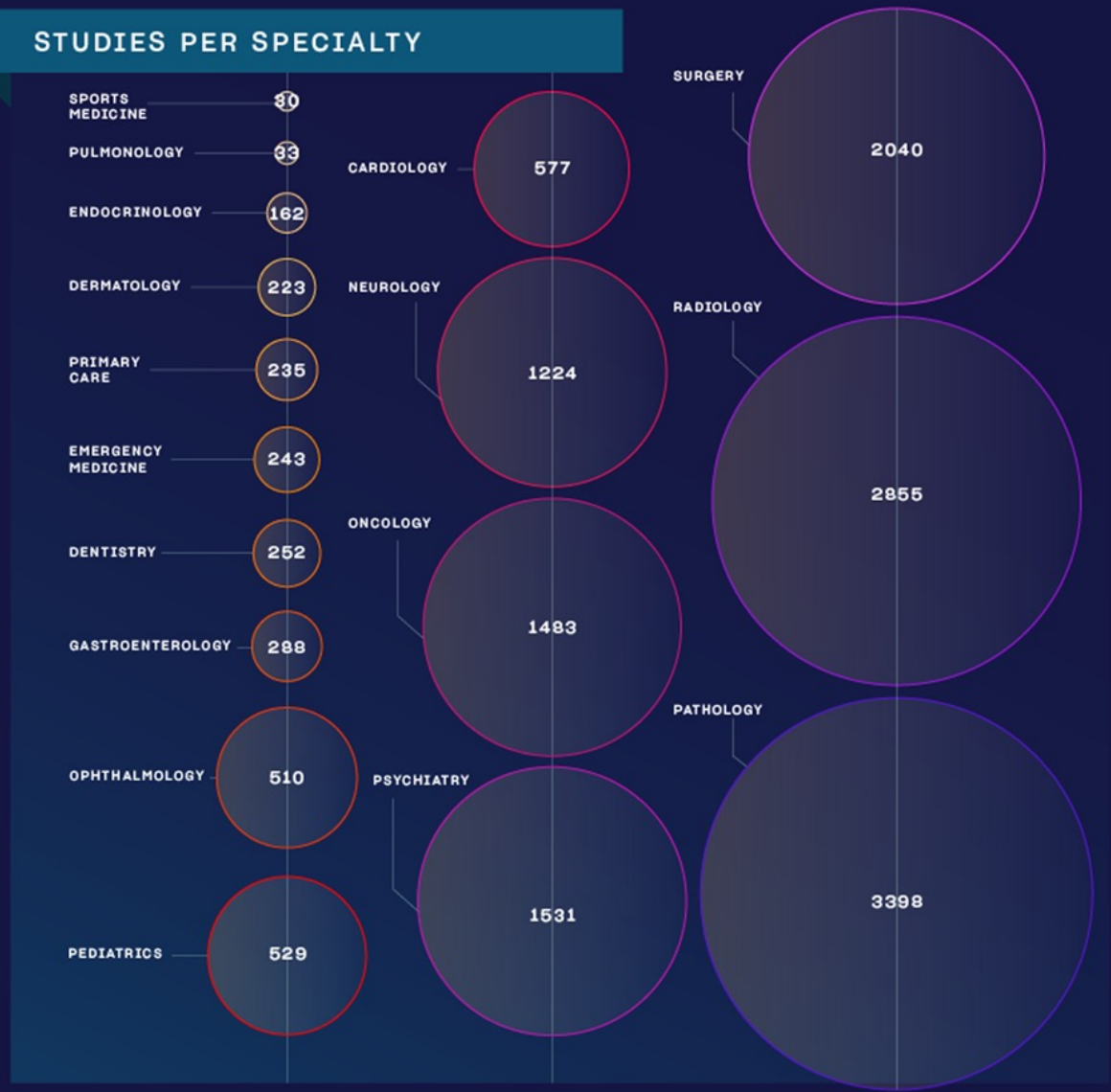
b

MACHINE AND DEEP LEARNING STUDIES ON PUBMED.COM

TOTAL NUMBER OF STUDIES

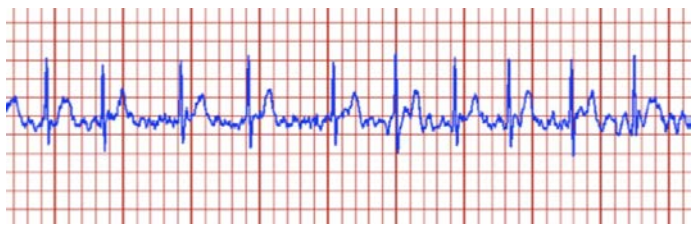


STUDIES PER SPECIALTY



DATA! DATA! DATA!

“ML is capable of making sense of an immense amount of high-content biological data, most of which is too high-dimensional for humans to interpret.” - Daphne Koller



Risk Factor	$CHADS_2$ (Maximum score, 6) Points	CHA_2DS_2-VASc (Maximum score, 9) Points
Congestive heart failure	1	1
Hypertension	1	1
Diabetes	1	1
Vascular disease	N/A	1
Age 65-74	N/A	1
Age ≥75	1	2
Female sex	N/A	1
Previous stroke/TIA	2	2

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ANNALS OF MEDICINE NOVEMBER 12, 2018 ISSUE

WHY DOCTORS HATE THEIR COMPUTERS

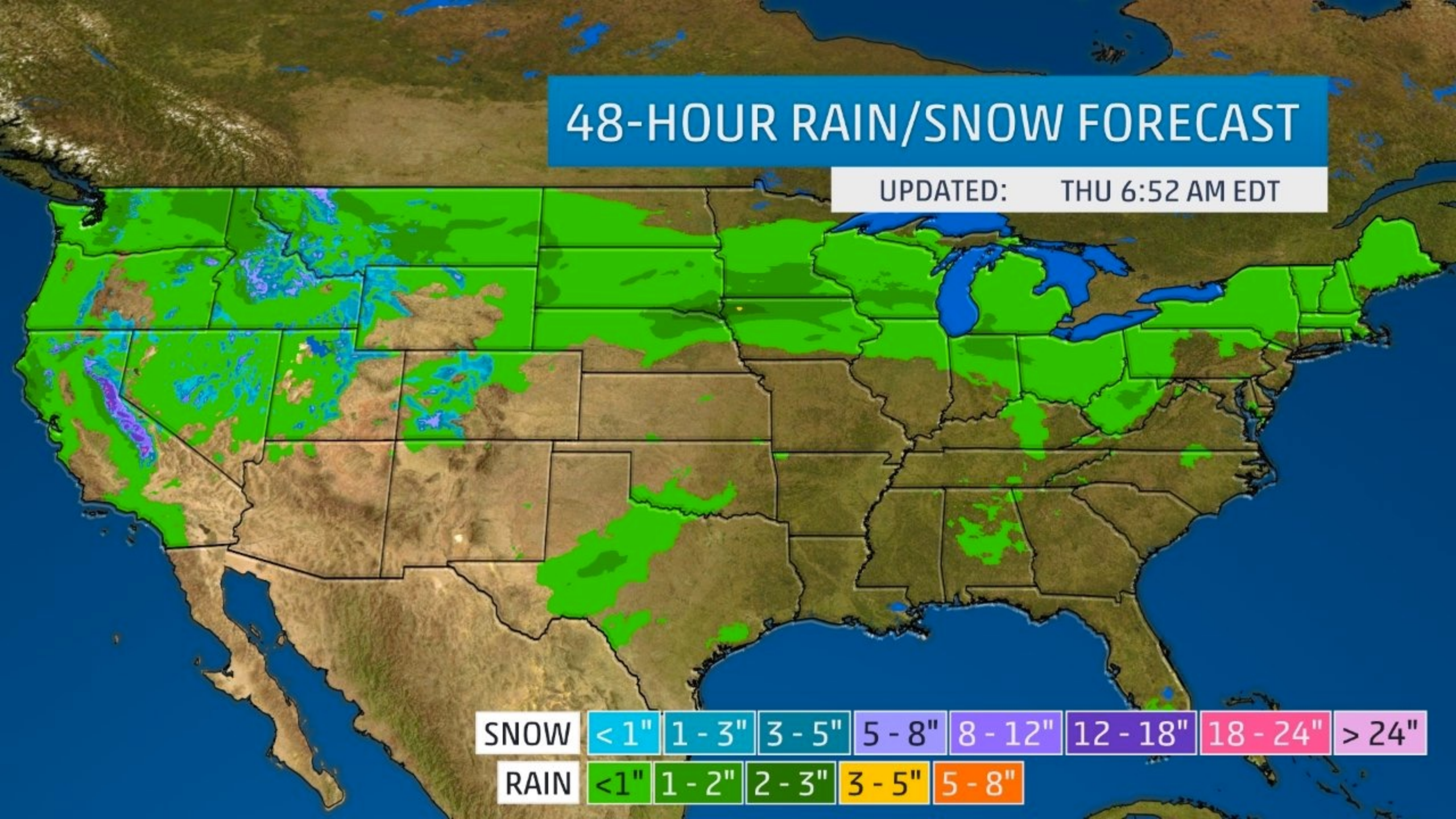
Digitization promises to make medical care easier and more efficient. But are screens coming between doctors and patients?

By Atul Gawande

Why Doctors Hate Their Computers

"I've come to feel that a system that promised to increase my mastery over my work has, instead, increased my work's mastery over me."

What if the convergence of the digitial transformation in medicine and machine learning could improve health outcomes, improve access, and reduce costs?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Smarter with every patient interaction

With every

purchase on

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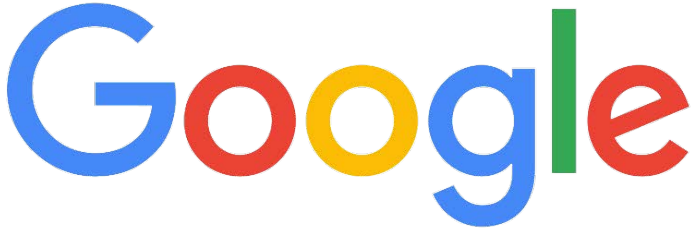
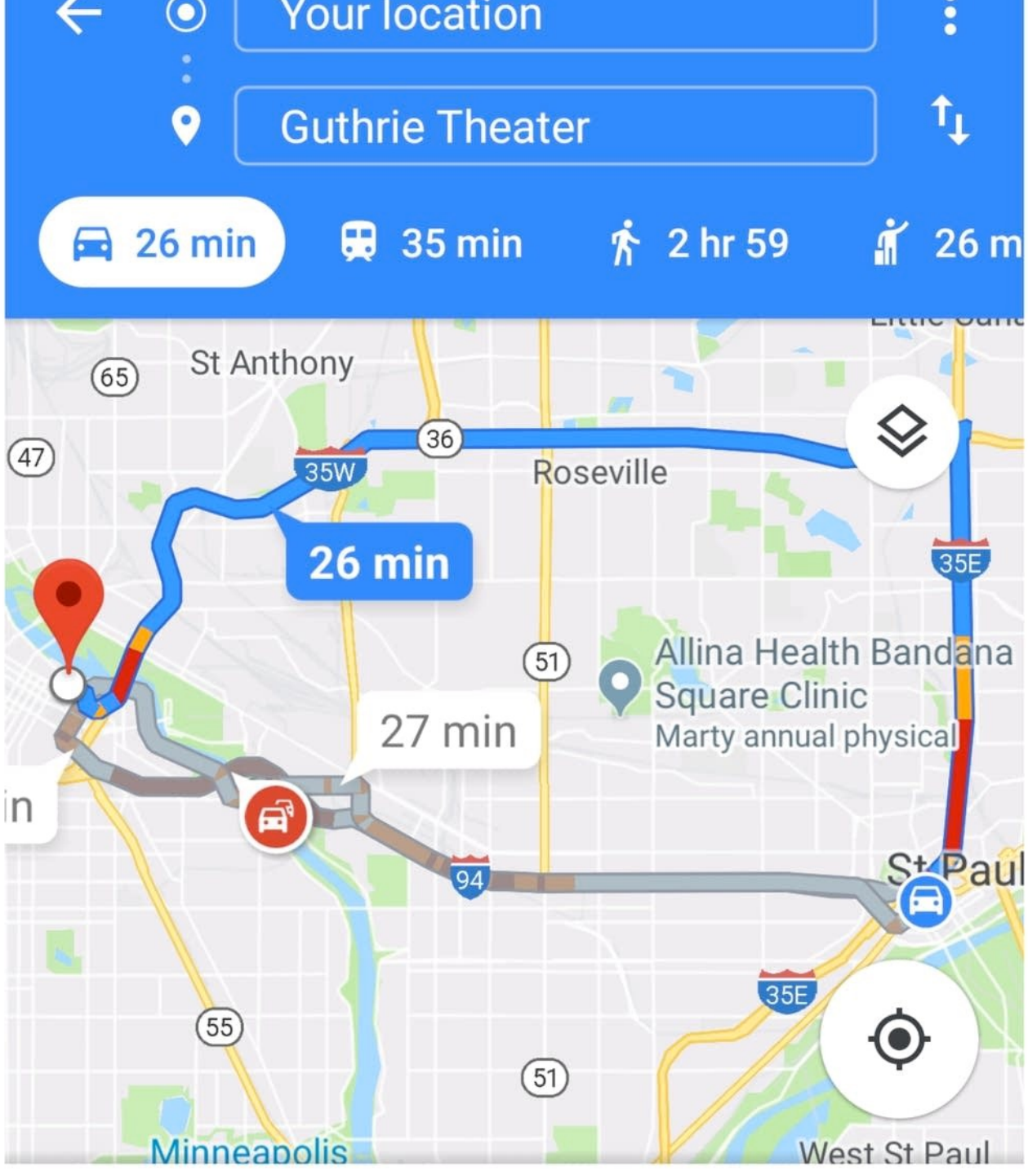


mile driven on

they get **smarter**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St Paul
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Minneapolis
West St Paul

Proceed to highlighted route
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E Minnehaha
30 MPH
E Arch St
Linden St
University Ave E
University Ave
Regions Hospital
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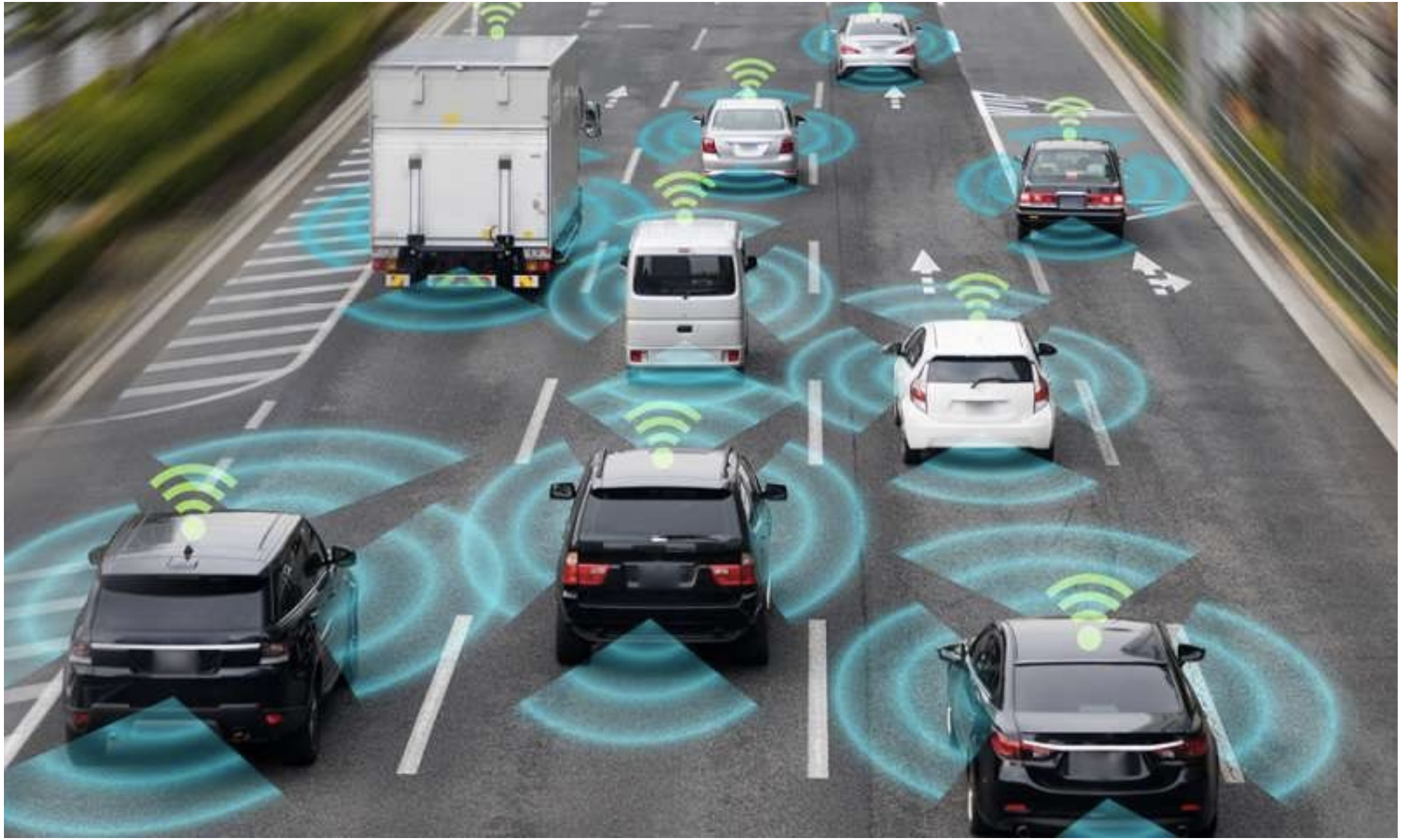

“The digital transformation of healthcare has the potential to make healthcare more humane and personalized.”

npj | Digital Medicine

www.nature.com/npjdigitalmed

PERSPECTIVE OPEN

The digital transformation of medicine can revitalize the patient-clinician relationship

Haider J. Warraich[1,2], Robert M. Califf[3,4,5] and Harlan M. Krumholz[6]

Health professionals within the medical community feel that the principles of humanism in medicine have not been a point of emphasis for information and computer technology in healthcare. There is concern that the electronic health record is eroding the patient-clinician relationship and distancing clinicians from their patients. New analytic technologies, on the contrary, by taking over repetitive and mundane tasks, can provide an avenue to make medical care more patient-centered by freeing clinicians' time, and the time of the whole clinical care team, to engage with patients. Technology such as advanced speech recognition that optimizes clinicians' workflow could revitalize the patient-clinician relationship and perhaps also improve clinician well-being. Digital phenotyping can gain invaluable additional data from patients using technology that is already used for personal reasons by the majority of patients. The digital transformation of healthcare has the potential to make healthcare more humane and personalized, however, several important steps are needed to avoid the pitfalls that have come with prior iterations of information technology in medicine such as a heightened emphasis on data security and transparency. Both patients and clinicians should be involved from the early stages of development of medical technologies to ensure that they are person-centric. Technologists and engineers developing healthcare technologies should have experiences with the delivery of healthcare and the lives of patients and clinicians. These steps are necessary to develop a common commitment to the design concept that technology and humane care are not mutually exclusive, and in fact, can be symbiotic.

npj Digital Medicine (2018)1:49 ; doi:10.1038/s41746-018-0060-2

Original Investigation | Cardiology

Comparison of Machine Learning Methods With National Cardiovascular Data Registry Models for Prediction of Risk of Bleeding After Percutaneous Coronary Intervention

Bobak J. Mortazavi, PhD; Emily M. Bucholz, MD, PhD, MPH; Nihar R. Desai, MD, MPH; Chenxi Huang, PhD; Jeptha P. Curtis, MD; Frederick A. Masoudi, MD, MSPH; Richard E. Shaw, MA, PhD; Sahand N. Negahban, PhD; Harlan M. Krumholz, MD, SM

Abstract

IMPORTANCE Better prediction of major bleeding after percutaneous coronary intervention (PCI) may improve clinical decisions aimed to reduce bleeding risk. Machine learning techniques, bolstered by better selection of variables, hold promise for enhancing prediction.

OBJECTIVE To determine whether machine learning techniques better predict post-PCI major bleeding compared with the existing National Cardiovascular Data Registry (NCDR) models.

DESIGN, SETTING, AND PARTICIPANTS This comparative effectiveness study used the NCDR CathPCI Registry data version 4.4 (July 1, 2009, to April 1, 2015), machine learning techniques were used (logistic regression with lasso regularization and gradient descent boosting [XGBoost, version 0.71.2]), and output was then compared with the existing simplified risk score and full NCDR models

Key Points

Question Can machine learning techniques, bolstered by better selection of variables, improve prediction of major bleeding after percutaneous coronary intervention (PCI)?

Findings In this comparative effectiveness study that modeled more than 3 million PCI procedures, machine learning techniques improved the prediction of post-PCI major bleeding to

Viewpoint

Agile Health Care Analytics: Enabling Real-Time Disease Surveillance With a Computational Health Platform

Wade L Schulz[1,2], MD, PhD; Thomas J S Durant[1,2], MD; Charles J Torre Jr[1,3], MS; Allen L Hsiao[3,4], MD; Harlan M Krumholz[2,5,6], SM, MD

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Schulz *et al. BMC Med Inform Decis Mak* (2021) 21:61
https://doi.org/10.1186/s12911-021-01416-x

BMC Medical Informatics and Decision Making

RESEARCH ARTICLE Open Access

Temporal relationship of computed and structured diagnoses in electronic health record data

Wade L. Schulz[1,2], H. Patrick Young[2,3], Andreas Coppi[2,3], Bobak J. Mortazavi[2,3,4,5], Zhenqiu Lin[2], Raymond A. Jean[2,6] and Harlan M. Krumholz[2,3,7*]

Abstract

Background: The electronic health record (EHR) holds the prospect of providing more complete and timely access to clinical information for biomedical research, quality assessments, and quality improvement compared to other

Journal of the American Heart Association

ORIGINAL RESEARCH

Leveraging the Electronic Health Records for Population Health: A Case Study of Patients With Markedly Elevated Blood Pressure

Yuan Lu, ScD; Chenxi Huang, PhD; Shiwani Mahajan, MBBS; Wade L. Schulz, MD, PhD; Khurram Nasir, MD; Erica S. Spatz, MD, MHS; Harlan M. Krumholz, MD, SM

BACKGROUND: The digital transformation of medical data provides opportunities to perform digital population health surveillance and identify people inadequately managed in usual care. We leveraged the electronic health records of a large health system to identify patients with markedly elevated blood pressure and characterize their follow-up care pattern.

Accuracy of Computable Phenotyping Approaches for SARS-CoV-2 Infection and COVID-19 Hospitalizations from the Electronic Health Record

Rohan Khera MD MS[1,2$], Bobak J. Mortazavi PhD[2,3$], Veer Sangha[1], Frederick Warner PhD[2], H. Patrick Young PhD[2], Joseph S. Ross MD MHS[2,4,5], Nilay D. Shah PhD[6], Elitza S. Theel PhD,[7] William G. Jenkinson PhD,[8] Camille Knepper MS,[6] Karen Wang MD MHS[9,10], David Peaper MD PhD,[10,11] Richard A Martinello MD,[13] Cynthia A. Brandt MD MPH[10,12], Zhenqiu Lin PhD[1,2], Albert I. Ko MD,[14,15] Harlan M. Krumholz MD SM[1,2,5], Benjamin D. Pollock PhD[6,8§], Wade L. Schulz MD PhD[2,10,11§*]

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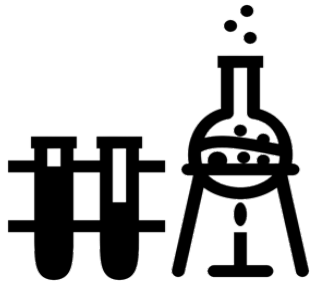
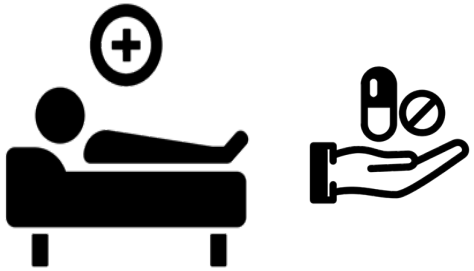
[5]

Bench-to-Bedside



Bench



Bedside

Calculation-to-Clinic

CALCULATION

CLINIC

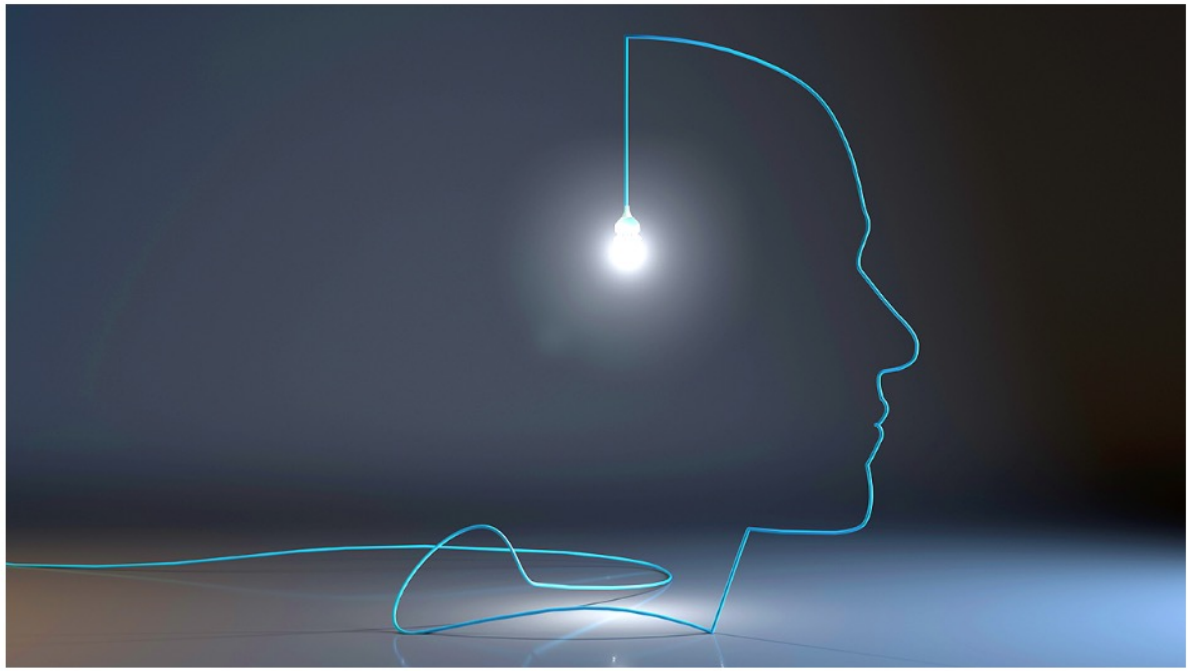
CHANGE MANAGEMENT

Digital Transformation Is Not About Technology

by Behnam Tabrizi, Ed Lam, Kirk Girard, and Vernon Irvin

MARCH 13, 2019

Summary Save Share 26 Comment Text Size Print



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A recent survey of directors, CEOs, and senior executives found that digital transformation (DT) risk is their #1 concern in 2019. Yet 70% of all DT initiatives do not reach their goals. Of the $1.3 trillion that was spent on DT last year, it was estimated that $900 billion went to waste. Why do some DT efforts succeed and others fail?

Fundamentally, it's because most digital technologies provide *possibilities* for efficiency gains and customer intimacy. But if people lack the right mindset to change and the current organizational practices are flawed, DT will simply magnify those flaws. Five key lessons have helped us lead our organizations through digital transformations that succeeded.

RAPID-LEARNING AGENDA

By Harlan M. Krumholz

Big Data And New Knowledge In Medicine: The Thinking, Training, And Tools Needed For A Learning Health System

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NO. 7 (2014): 1163–1170
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The People-to-People Health
Foundation, Inc.

ABSTRACT **Big data in medicine—massive quantities of health care data accumulating from patients and populations and the advanced analytics that can give those data meaning—hold the prospect of becoming an engine for the knowledge generation that is necessary to address the extensive unmet information needs of patients, clinicians, administrators, researchers, and health policy makers. This article explores the ways in which big data can be harnessed to advance prediction, performance, discovery, and comparative effectiveness research to address the complexity of patients, populations, and organizations. Incorporating big data and next-generation analytics into clinical and population health research and practice will require not only new data sources but also new thinking, training, and tools. Adequately utilized, these reservoirs of data can be a practically inexhaustible source of knowledge to fuel a learning health care system.**

Harlan M. Krumholz (Harlan.Krumholz@yale.edu) is the Harold H. Hines Jr. Professor of Medicine and Epidemiology and Public Health at the Yale University School of Medicine, in New Haven, Connecticut.

Conclusion

This is a historic moment in medicine. There is a remarkable opportunity to promote medicine as an information science and strengthen the foundations of a learning health care system, defined by the Institute of Medicine as one "designed to generate and apply the best evidence for the collaborative healthcare choices of each patient and provider; to drive the process of discovery as a natural outgrowth of patient care; and to ensure innovation, quality, safety, and value in health care."[32]

Thank you.

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Center for Computational Health