Disruptive Technology in Healthcare: Artificial Intelligence and Robots

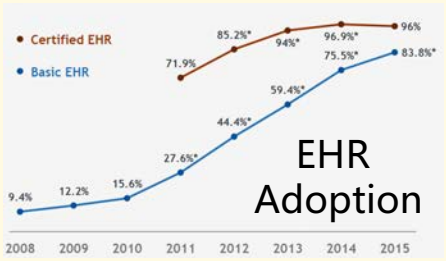
Jiajie Zhang, PhD

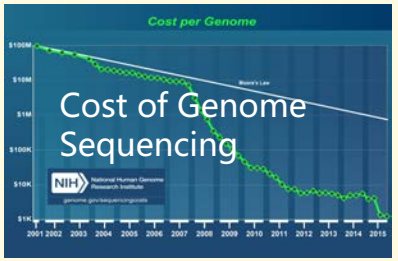
Dean & Professor
Glassell Family Foundation Distinguished Chair in Informatics Excellence
School of Biomedical Informatics

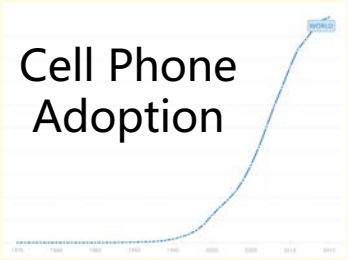
Outline

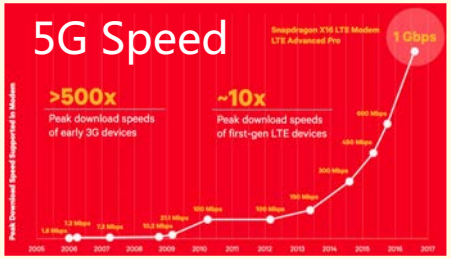
- The Age of Acceleration
- The Age of Disruption
- The AI Revolution
- Examples: Disruptive Technology in Healthcare
- Conclusion

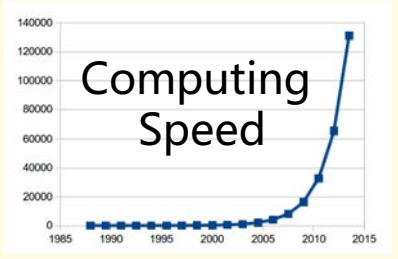
Today – The Age of Acceleration

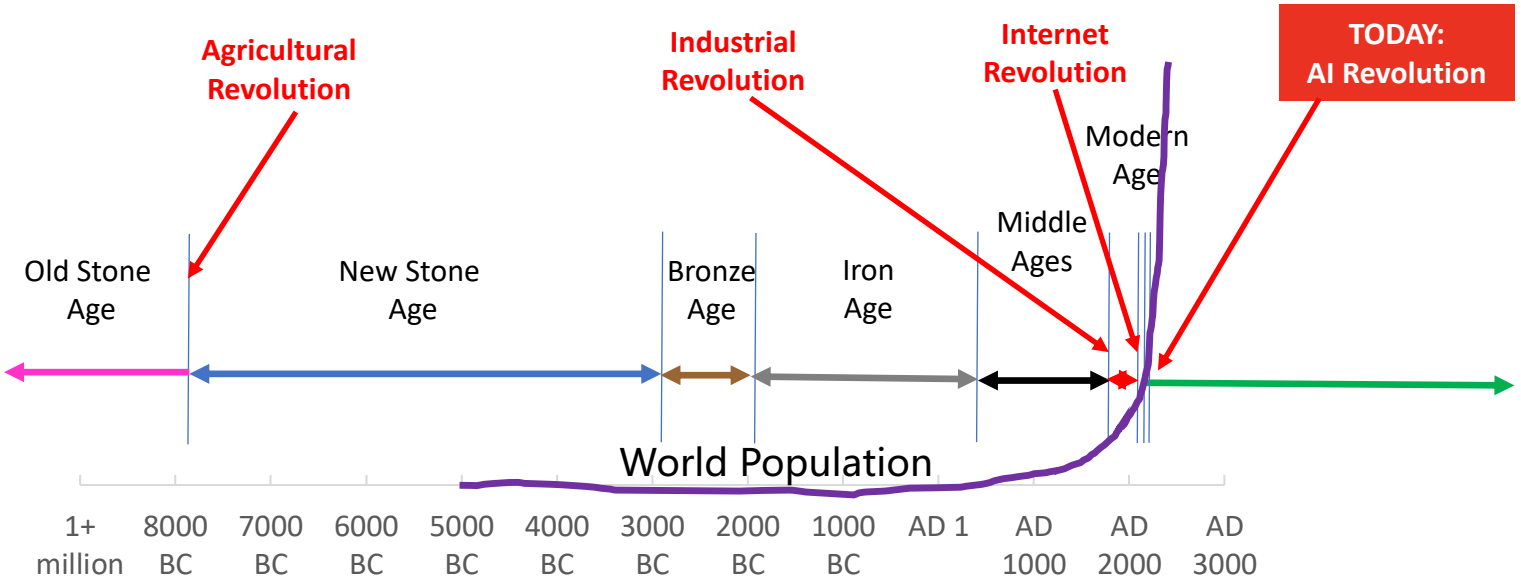












© Jiajie Zhang 2018

Today - The Age of Disruption

"The past 20 or 30 years, and the next 20 or 30 years—really is historically unique. It is arguably the **largest economic disruption in recorded human history.**"
(Ben Sasse, US Senator, WSJ, April 21, 2017)

Information
- Yahoo
- Google
- Baidu
- Wikipedia
- Digital Pub

Communication
- Email
- Facebook
- Twitter
- iMessage
- Skype
- WeChat

Retail
- Amazon
- Alibaba
- eBay
- JD.com

Entertainment
- iTunes
- NetFlix
- YouTube
- Spotify

Travel
- Expedia
- AirBnB
- Uber

Finance
- PayPal
- ApplePay
- AliPay
- WeChat Pay
- Banking
- Credit
- Investment

Education
- MOOC
- edX
- Coursera
- Hybrid
- Modular

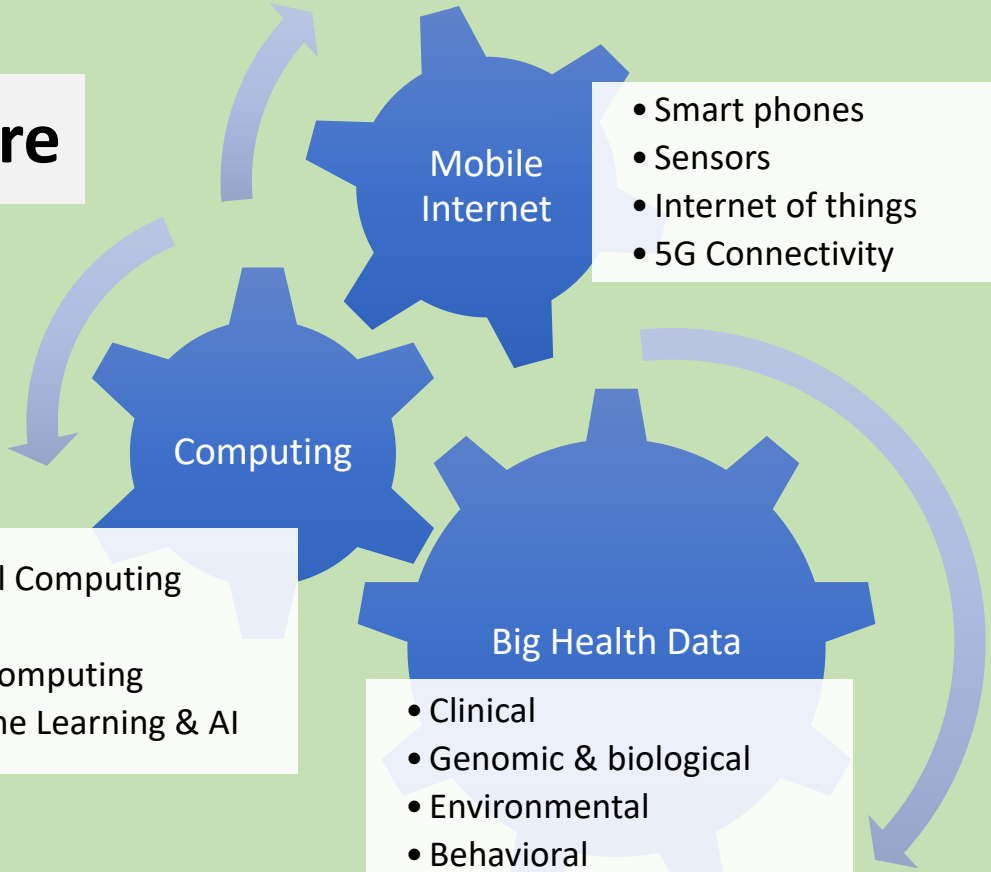
Healthcare
- EPIC/Cerner
- Optum
- IBM Watson
- 23andme
- VisualDx

The biggest companies in these industries are all IT companies today.

© Jiajie Zhang 2018

Three Drivers for the AI Revolution

Healthcare



© Jiajie Zhang 2018

The Many "Revolutions" of Artificial Intelligence

2017
Google AlphaGo

1997
IBM Deep Blue

2012
ImageNet

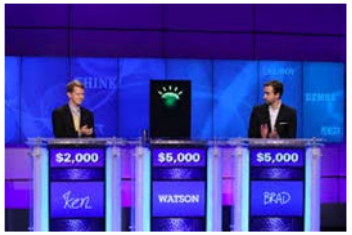
Minsky & Papert

1969
MIT

1986
UCSD
Backpropagation

1956
Dartmouth

2011
IBM Watson



1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 **2010** 2015

© Jiajie Zhang 2018

Speak now

This Is Us

this is a strategically

this is a strategic retreat

this is a strategic Retreat session footage

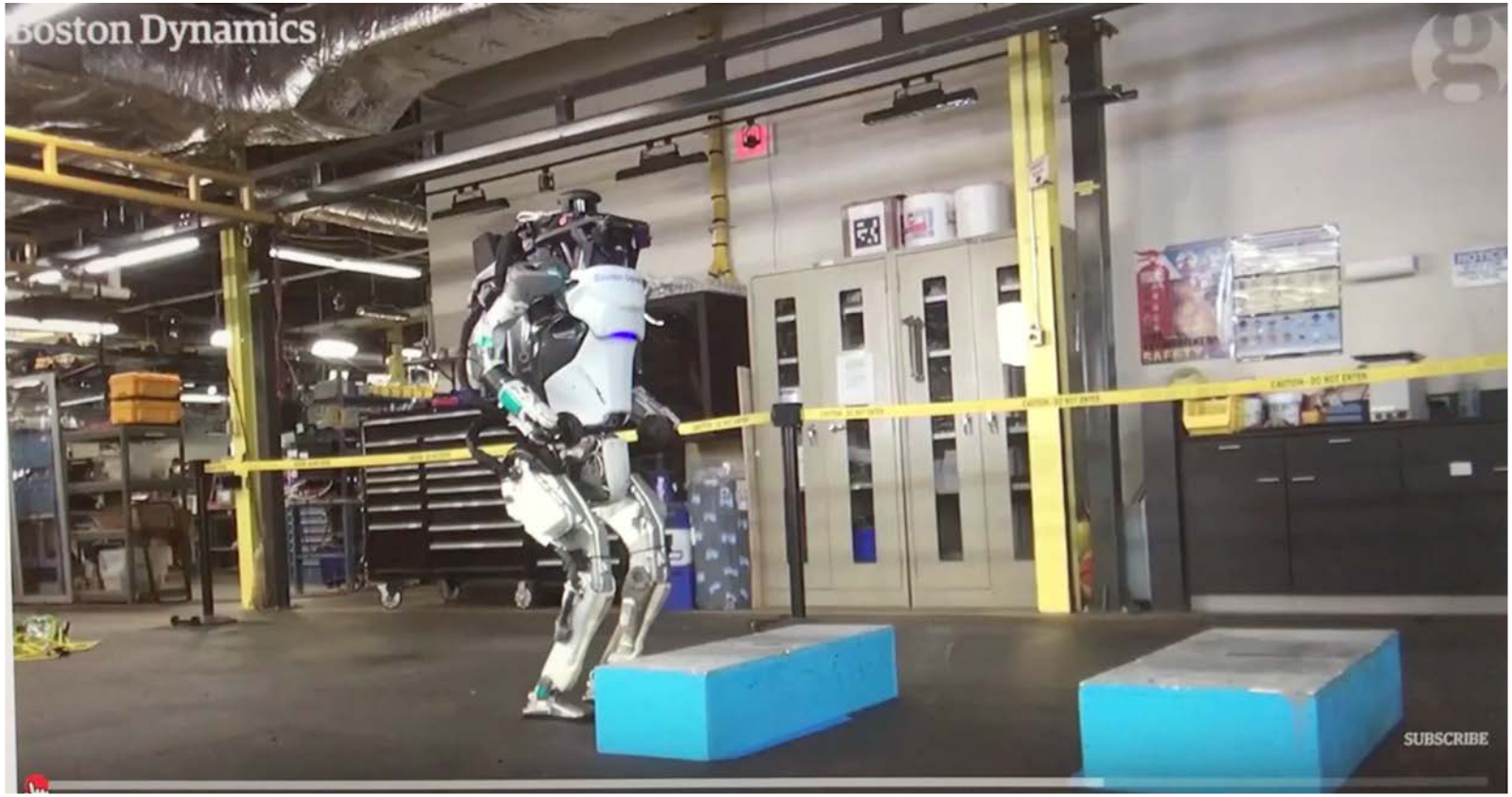
this is a strategic Retreat session for the University

this is a strategic Retreat session for the University of Texas Health Science Center at Houston

Autonomous Vehicle

(NVidia CES 2018 Demo)

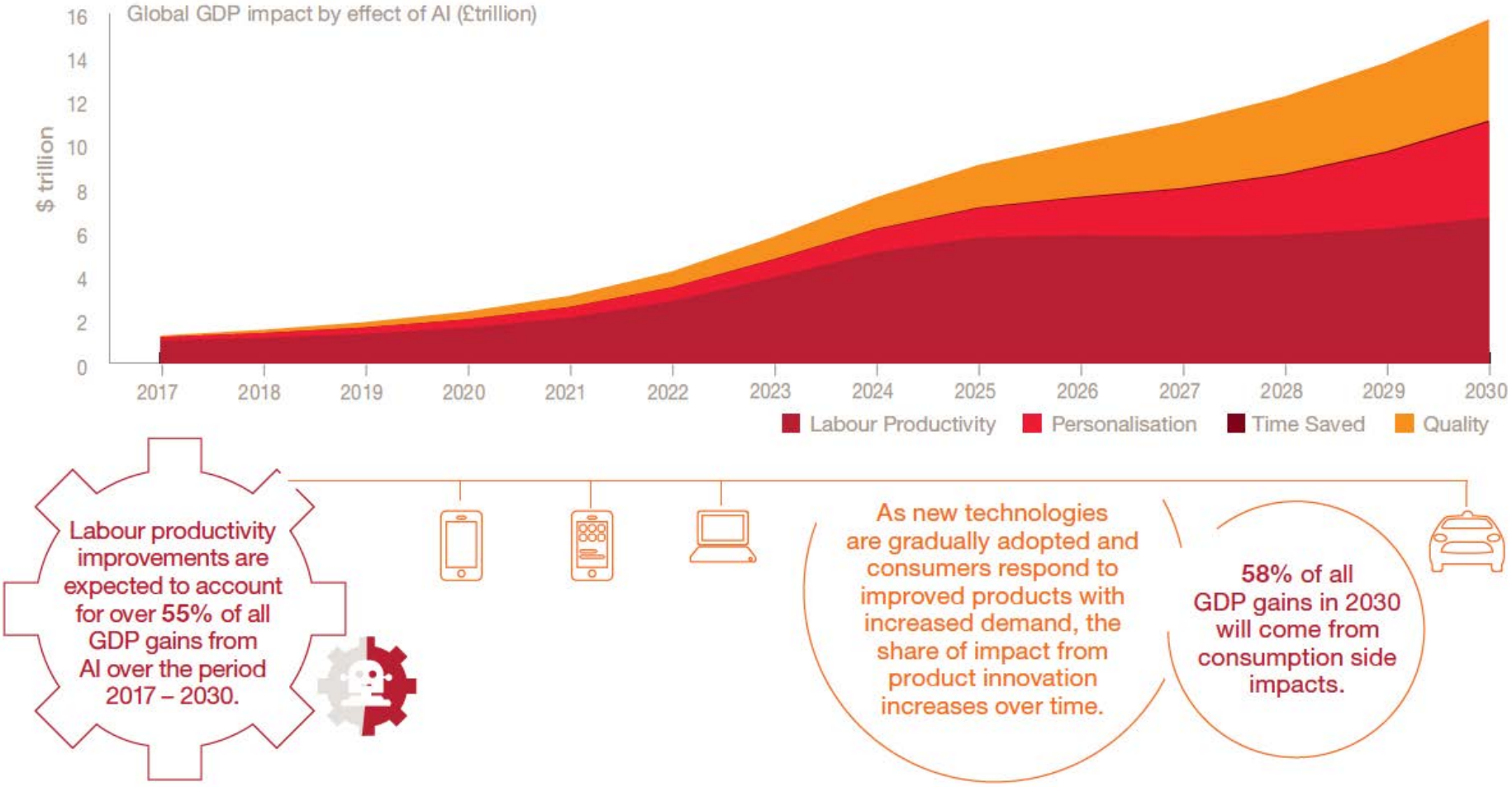
- 1.25 million lives could be saved per year
- 157 hours commute time per person per year
- $150 B fuel cost saving in US in one year



https://www.youtube.com/watch?v=68F-UUU_Ff4

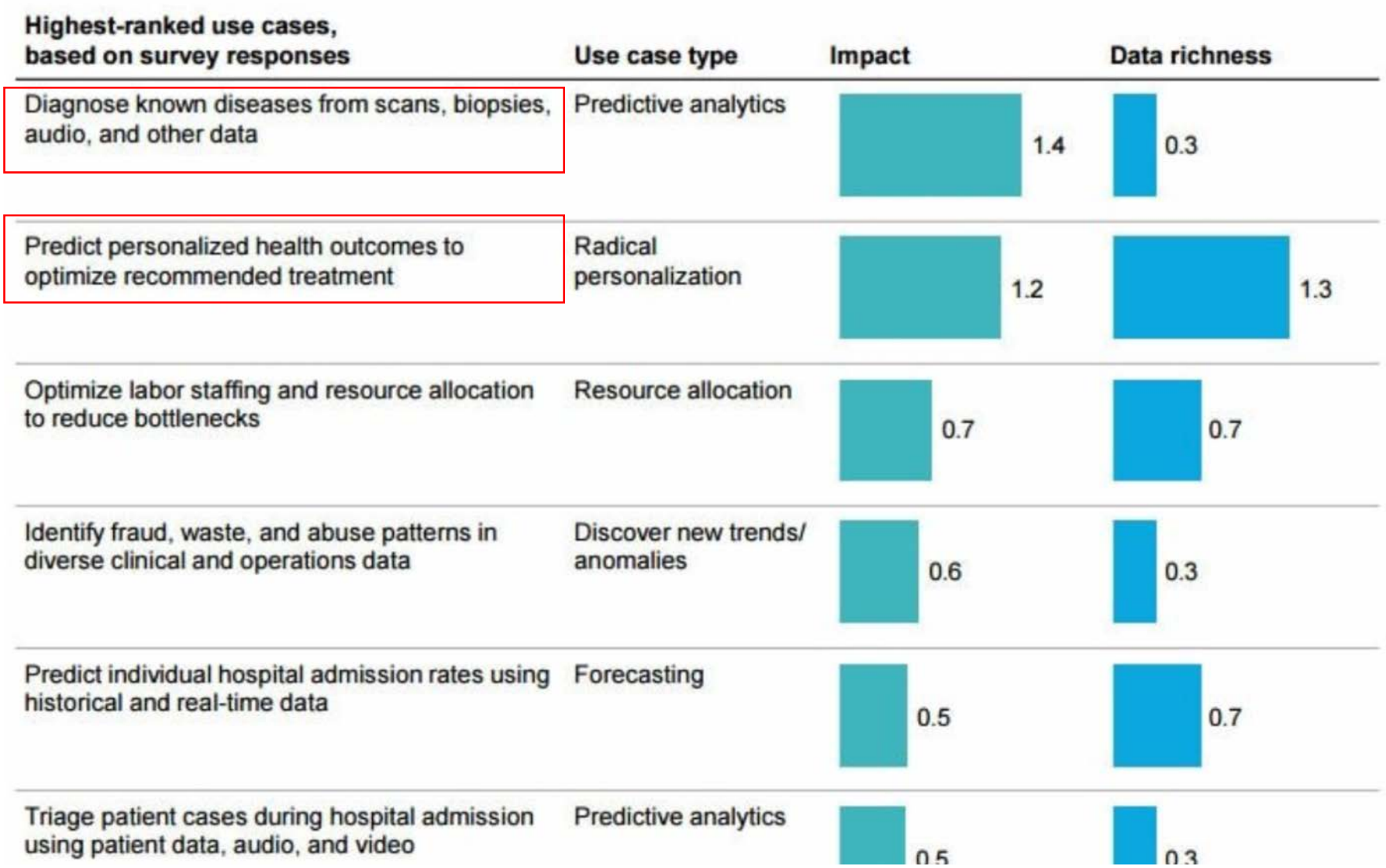
Impact of AI on Global GDP (PwC)

Figure 1: Where will the value gains come from with AI?



Source: PwC analysis

Impact of AI on Healthcare (McKinsey)



Highest-ranked use cases, based on survey responses	Use case type	Impact	Data richness
Diagnose known diseases from scans, biopsies, audio, and other data	Predictive analytics	1.4	0.3
Predict personalized health outcomes to optimize recommended treatment	Radical personalization	1.2	1.3
Optimize labor staffing and resource allocation to reduce bottlenecks	Resource allocation	0.7	0.7
Identify fraud, waste, and abuse patterns in diverse clinical and operations data	Discover new trends/ anomalies	0.6	0.3
Predict individual hospital admission rates using historical and real-time data	Forecasting	0.5	0.7
Triage patient cases during hospital admission using patient data, audio, and video	Predictive analytics	0.5	0.3

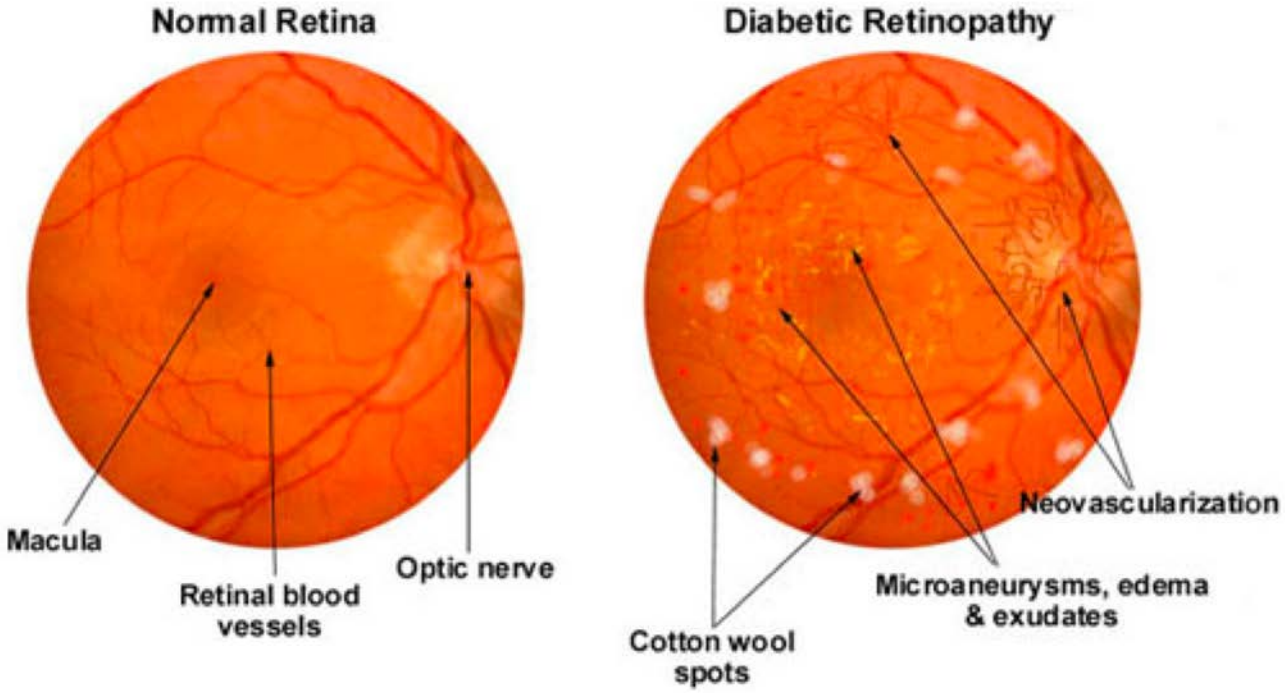
Examples of Disruptive Technology in Healthcare

- Imaging
- Natural Language Processing (NLP)
- Computational Phenotyping
- Prediction
- Computational Biomarker
- Population Health
- Precision Medicine
- Medical Education
- Physician Robot Companion

AI to medicine today is like microscope to life sciences in 1600s:

REEXAMINE AND REDISCOVER EVERYTHING ANEW

Imaging



December 13, 2016

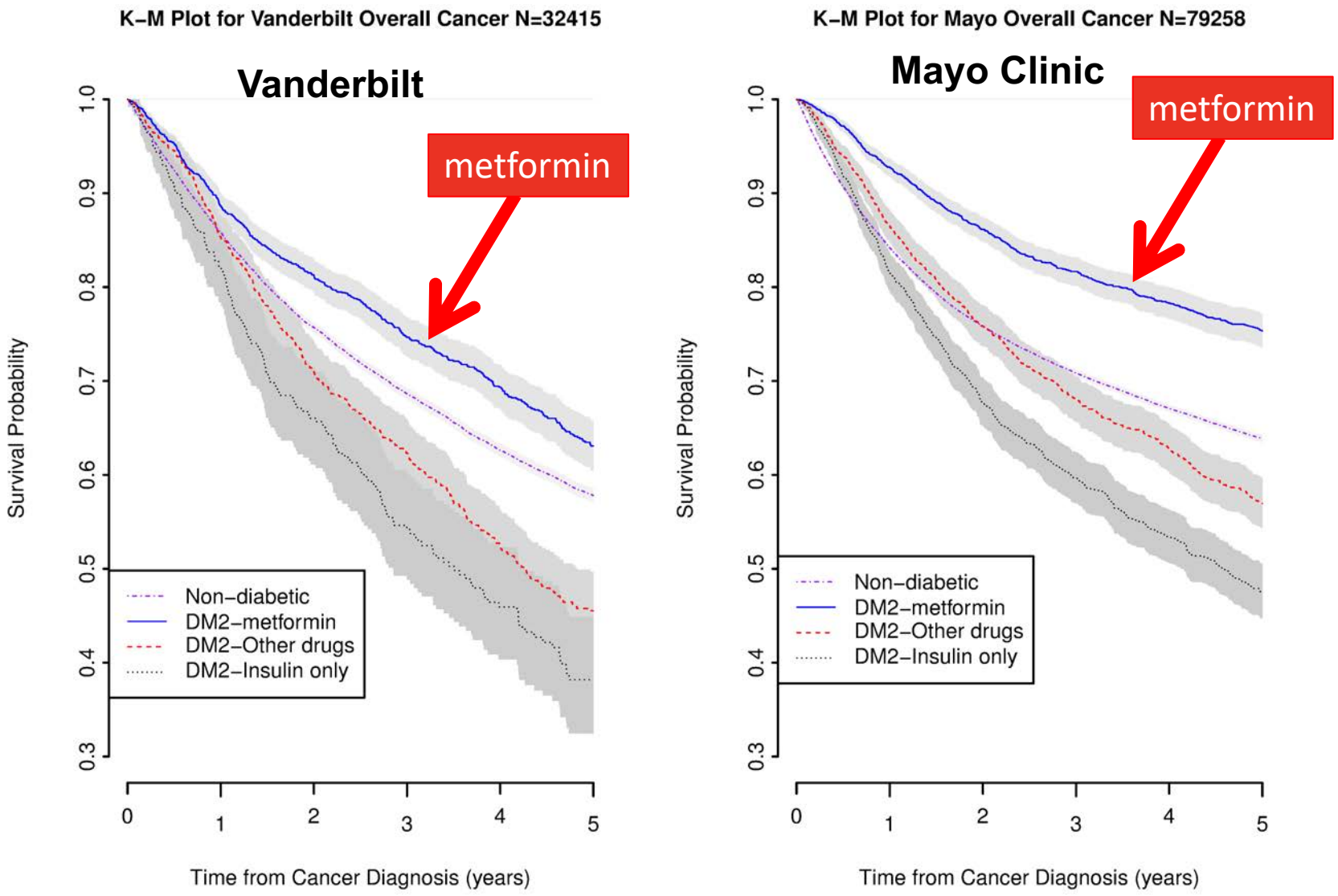
Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan, PhD[1]; Lily Peng, MD, PhD[1]; Marc Coram, PhD[1]; et al

≫ Author Affiliations | Article Information

JAMA. 2016;316(22):2402-2410. doi:10.1001/jama.2016.17216

Natural Language Processing
- Comparative Effectiveness Research



Hua Xu et al. (2015). Validating drug repurposing signals using electronic health records: a case study of metformin associated with reduced cancer mortality. Journal of American Medical Informatics Association, 22 (1), 179–191

Computational Phenotyping from EHR Data

31,816 Patients x 169 Diagnoses x 471 Medications

Hyperlipidemia
Phenotype 1 (41.6% of patients)
Other Endocrine, Metabolic, and Nutritional Disorders
HMG CoA Reductase Inhibitors
Intestinal Cholesterol Absortpion Inhibitors
Fibric Acid Derivatives
Antihyperlipidemics - Combinations
Nicotinic Acid Derivatives
Bile Acid Sequestrants
Oil Soluble Vitamins

Moderate Hypertension
Phenotype 2 (31.5% of patients)
Hypertension
Beta Blockers Cardio-Selective
Angiotensin II Receptor Antagonists
Loop Diuretics
Potassium
Nitrates
Alpha-Beta Blockers
Vasodilators

Uncomplicated Diabetes
Phenotype 3 (17.6% of patients)
Diabetes with No or Unspecified Complications
Sulfonylureas
Biguanides
Diagnostic Tests
Insulin Sensitizing Agents
Diabetic Supplies
Meglitinide Analogues
Antidiabetic Combinations

Mild Hypertension
Phenotype 4 (31.1% of patients)
Hypertension
ACE Inhibitors
Thiazides and Thiazide-Like Diuretics

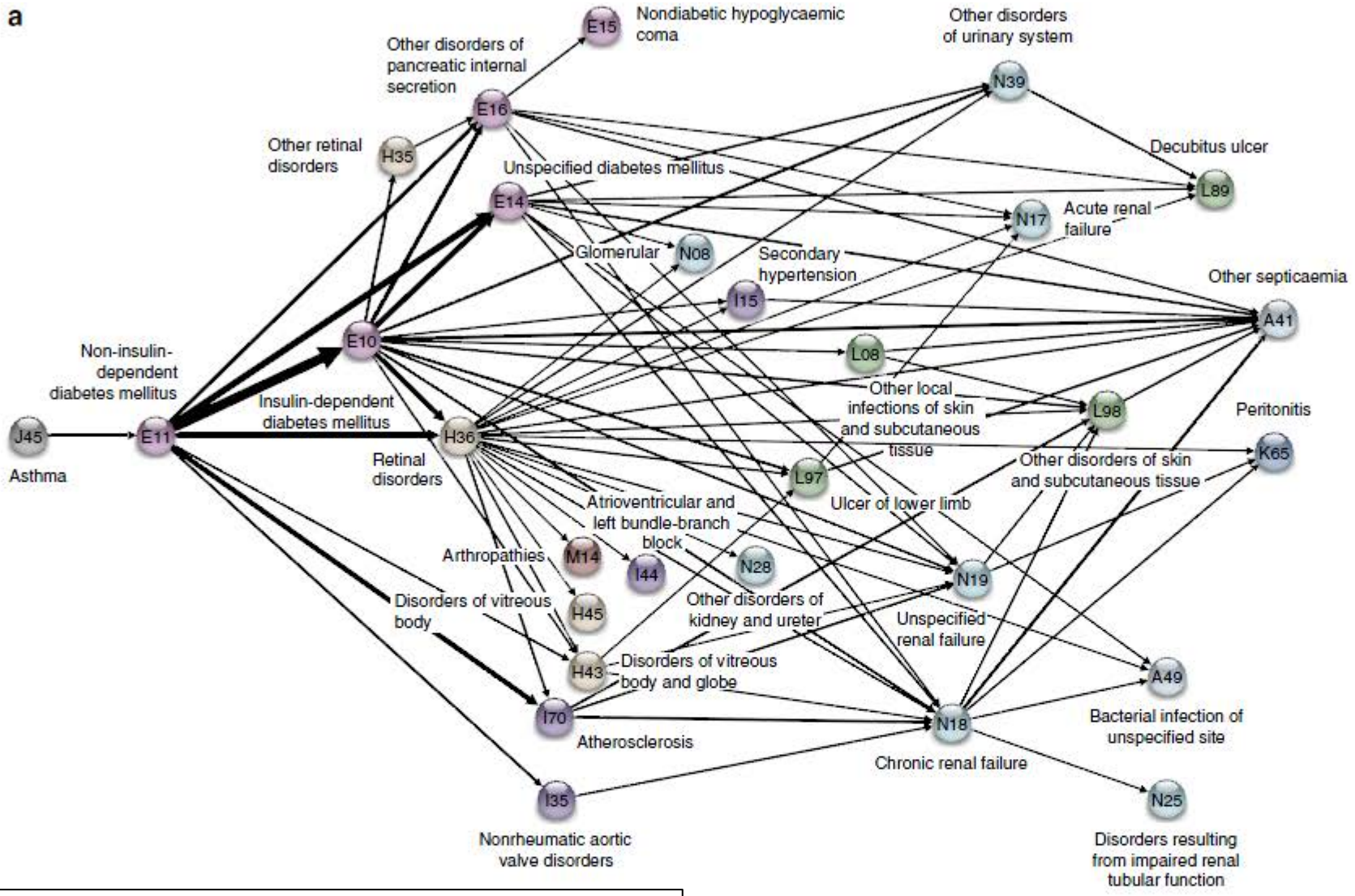
Chronic Respiratory Inflammation/Infection
Phenotype 5 (36.7% of patients)
Other Ear, Nose, Throat, and Mouth Disorders
Viral and Unspecified Pneumonia, Pleurisy
Significant Ear, Nose, and Throat Disorders
Cough/Cold/Allergy Combinations
Azithromycin
Fluoroquinolones
Sympathomimetics
Penicillin Combinations
Antitussives
Glucocorticosteroids
Tetracyclines
Anti-infective Misc. - Combinations
Clarithromycin
Cephalosporins - 2nd Generation
Cephalosporins - 1st Generation
Expectorants

Limestone: High-throughput candidate phenotype generation via tensor factorization

Joyce C. Ho [a], Joydeep Ghosh [a], Steve R. Steinhubl [b], Walter F. Stewart [c], Joshua C. Denny [d, e], Bradley A. Malin [d, f], Jimeng Sun [g]

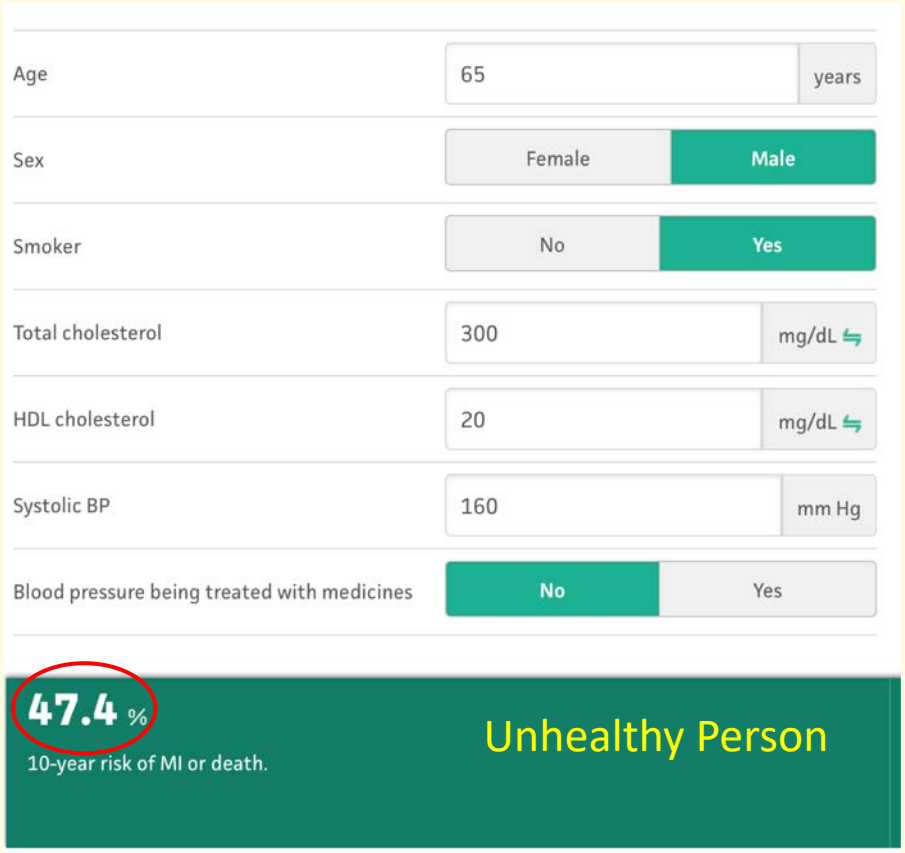
Journal of Biomedical Informatics
Volume 52, December 2014, Pages 199-211

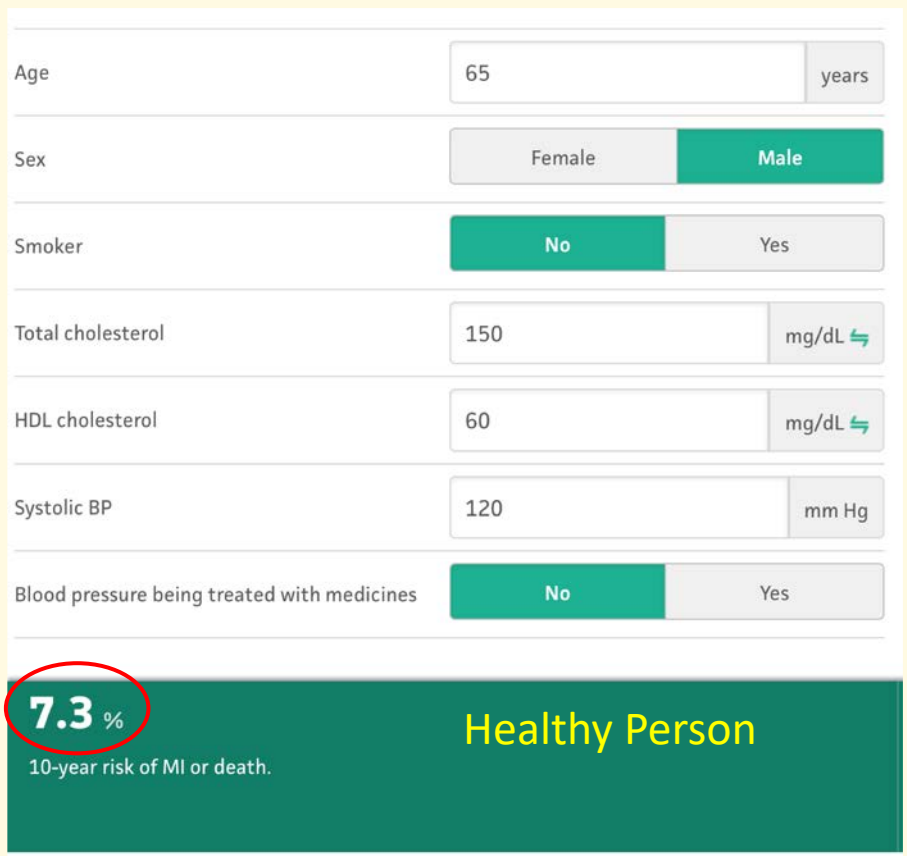
Prediction 1: Temporal Disease Trajectories
(6.2 million patients in Denmark)



(Jensen et al., 2014, Nature Communications)

Prediction 2: Risk Calculators from EHR Data





Can machine-learning improve cardiovascular risk prediction using routine clinical data?

Stephen F. Weng, Jenna Reps, Joe Kai, Jonathan M. Garibaldi, Nadeem Qureshi

Published: April 4, 2017 • https://doi.org/10.1371/journal.pone.0174944

Prediction 3: Sepsis

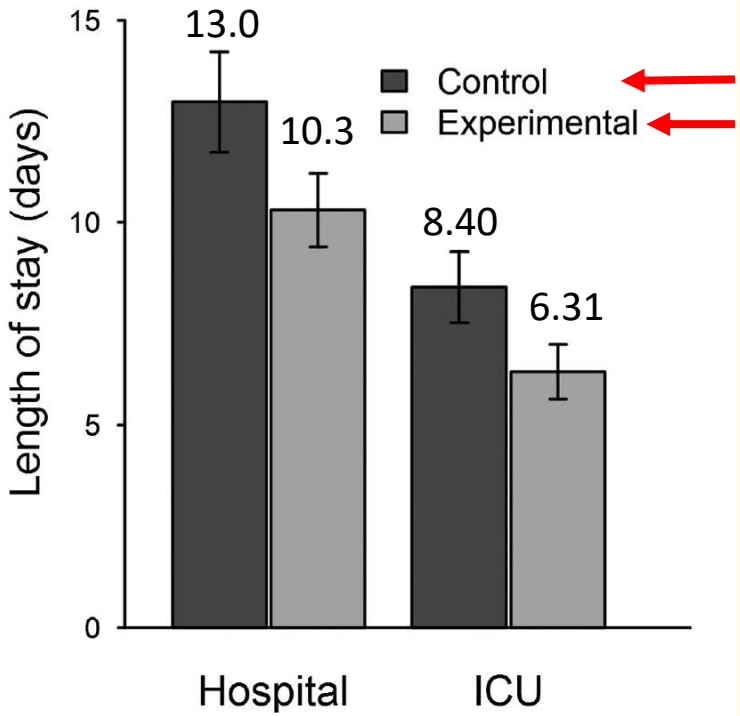


Figure 2 Decrease in average hospital and ICU length of stay with the use of the machine learning algorithm. The error bars represent one standard error above and below the mean length of stay. ICU, intensive care unit.

UCSF Severe Sepsis Detector
Machine Learning

Mortality

21.3%

↓

8.96%

Retrospective **Detection** (AUC)

MLA:	0.95
SIRS:	0.68
MEWS:	0.52
SOFA:	0.76
qSOFA:	0.52

New Machine Learning Algorithms for 4 Hour **Prediction** of Severe Sepsis:

Performance (AUC)

- Status Quo: 0.85
- Ongoing: 0.92

BMJ Open Respiratory Research

2017

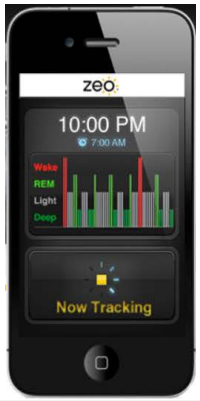
Effect of a machine learning-based severe sepsis prediction algorithm on patient survival and hospital length of stay: a randomised clinical trial

David W Shimabukuro,[1] Christopher W Barton,[2] Mitchell D Feldman,[3] Samson J Mataraso,[4,5] Ritankar Das[6]

Ongoing Project at UTHealth (Jiang, Dai, Murphy, Patel, Zhang, et al.)

Computational Biomarker: Sensors

Sleep Pattern Monitor



Ingestible Sensors (Proteus Digital)

PHOTO: PROTEUS DIGITAL HEALTH

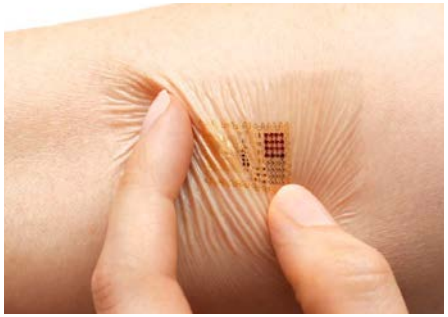
Vital Sign Tracker

Contact Lens for Glucose

Apple Watch

Fertility Thermometer

Bio Stamp for Vital Signs



Computational Biomarker: AF Detection

Presented by MDedge

CAREER | Search... | REGISTER OR LOGIN

Clinical Neurology News

Top news from ECTRIMS 2018

CONFERENCE COVERAGE

Smartphone device beat Holter for post-stroke AF detection

Publish date: October 18, 2018

By Mitchel L. Zoler; Clinical Neurology News

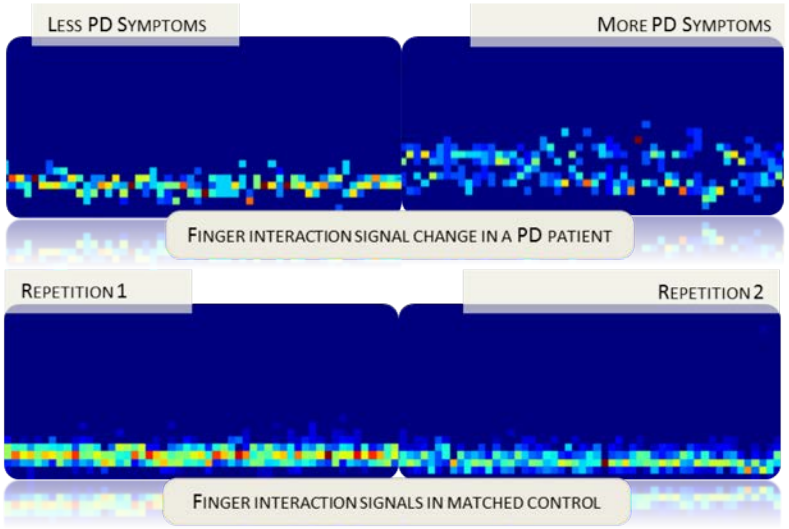
Computational Biomarker: Typing for Parkinson's

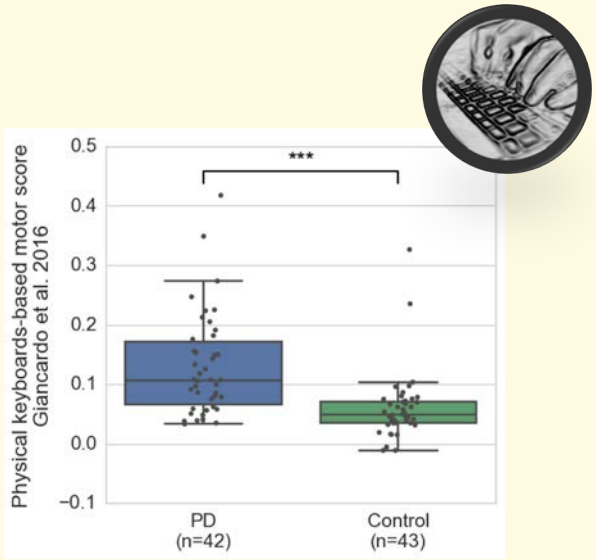
Typing data

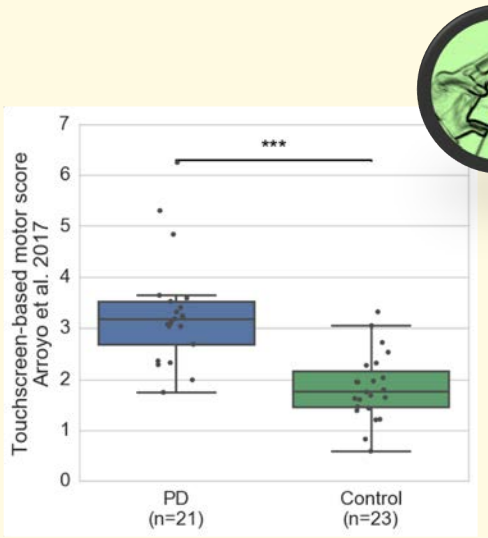
Low dimensional representation

Automatic Classifier/Regressor

Parkinson's Disease Typing Phenotype





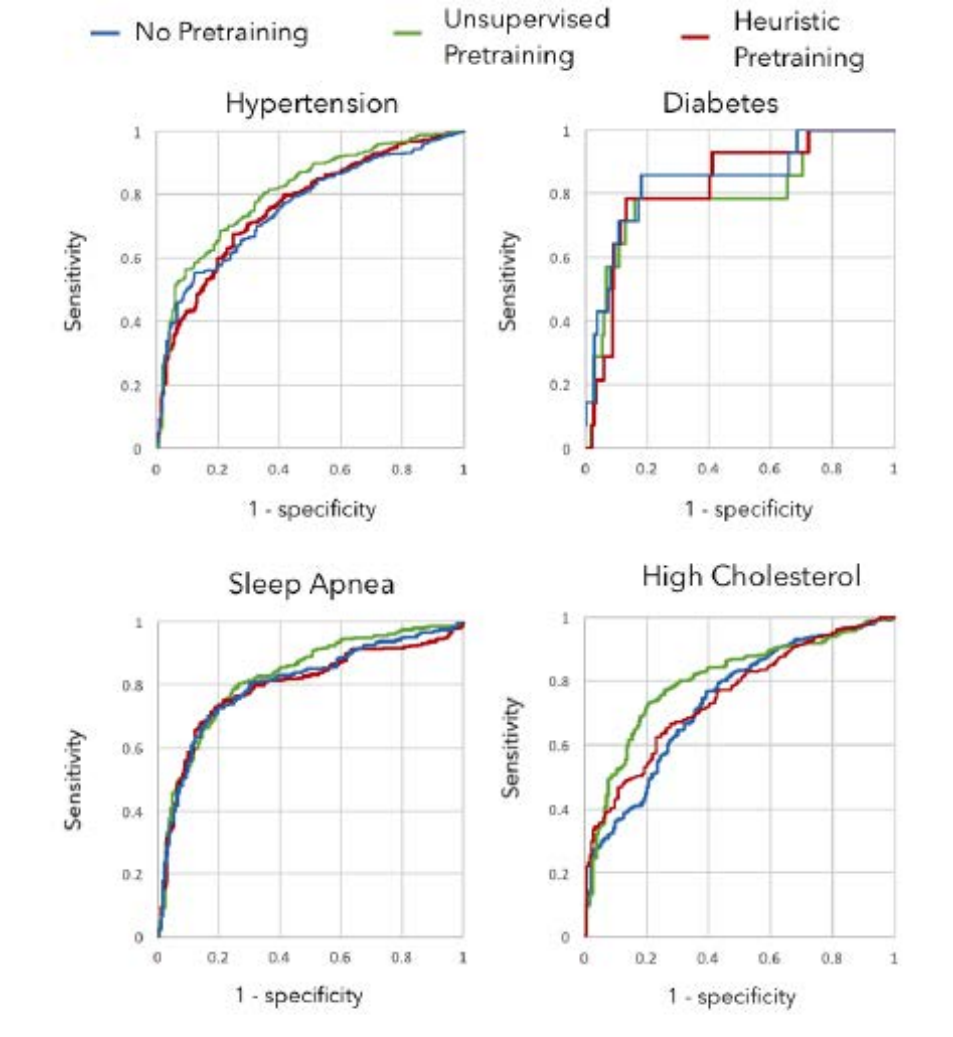


Giancardo et al., Psychomotor Impairment Detection via Finger Interactions with a Computer Keyboard During Natural Typing. Nature Scientific Reports, 2015.

Computational Biomarker: HRV

Heart Rate Variability, Deep Learning, and Disease Prediction

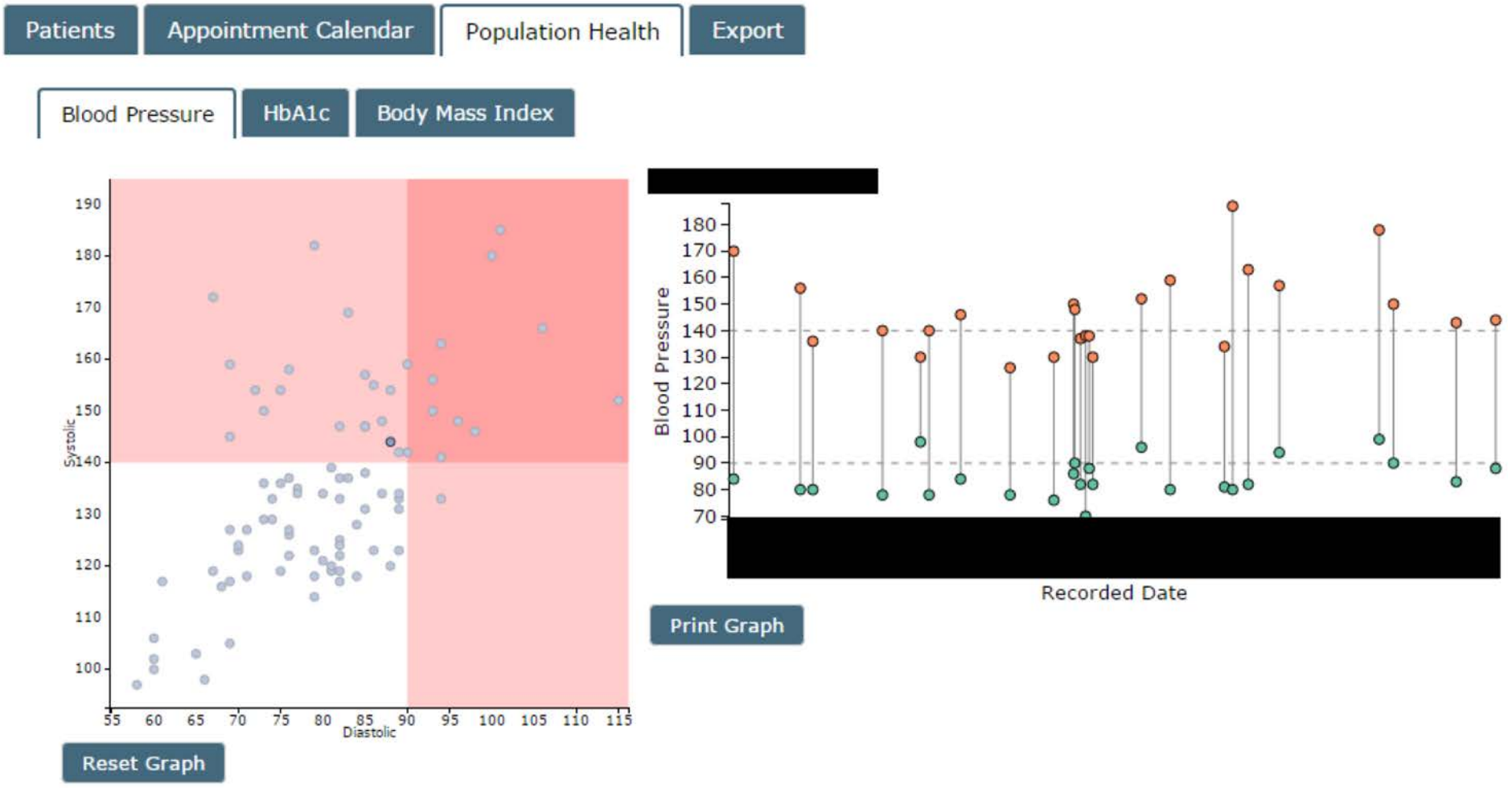
- Diabetes: 0.85 AUC
- Sleep apnea: 0.80 AUC
- Hypertension: 0.80 AUC
- High cholesterol: 0.67 AUC



Ballinger B, et al. DeepHeart: Semi-supervised sequence learning for cardiovascular risk prediction. Presented at: AAAI Conference on Artificial Intelligence; Feb. 2-7, 2018; New Orleans.

Population Health

- Chronic Disease Registry at UT Physicians



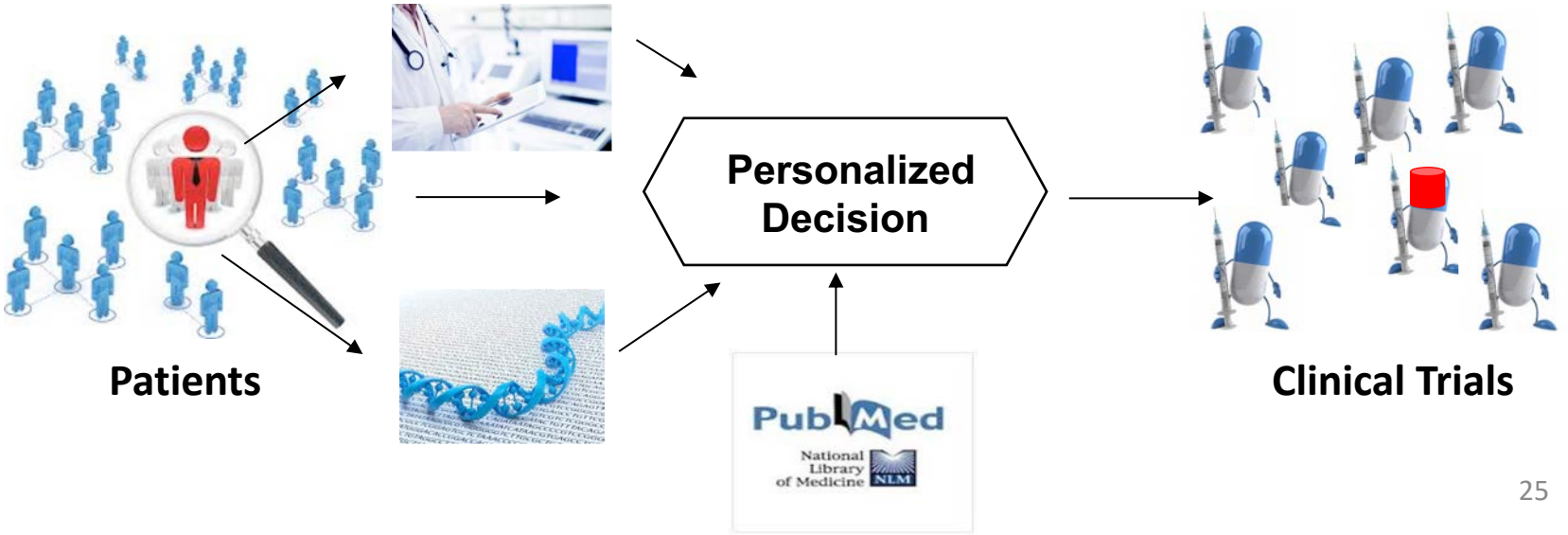
Interactive Graphs

Hwang, Bernstam, Johnson at UTHealth

Precision Medicine

- Cancer Clinical Trials Matching System

- UT MD Anderson and UTHealth
  - Dr. Funda Meric-Bernstam and Dr. Elmer Bernstam
- Using patient's genetic and clinical information to select the most appropriate clinical trials



Medical Education

Test Result

- Total Points: 600
- Passing Points: 360
- Robot: 456
- Top 5% among human takers

What is in the "Brain"

- Dozens of medical textbooks
- 2 million medical records
- 400,000 literature

CHINADAILY.COM.CN 中国日报网

US EUROPE AF
中文 双语 Franç

HOME CHINA WORLD BUSINESS LIFESTYLE CULTURE TRAVEL WATCHTHIS SPORTS OPINION RE

Business Macro Companies Industries Technology Motoring China Data Fir

Home / Business / Technology

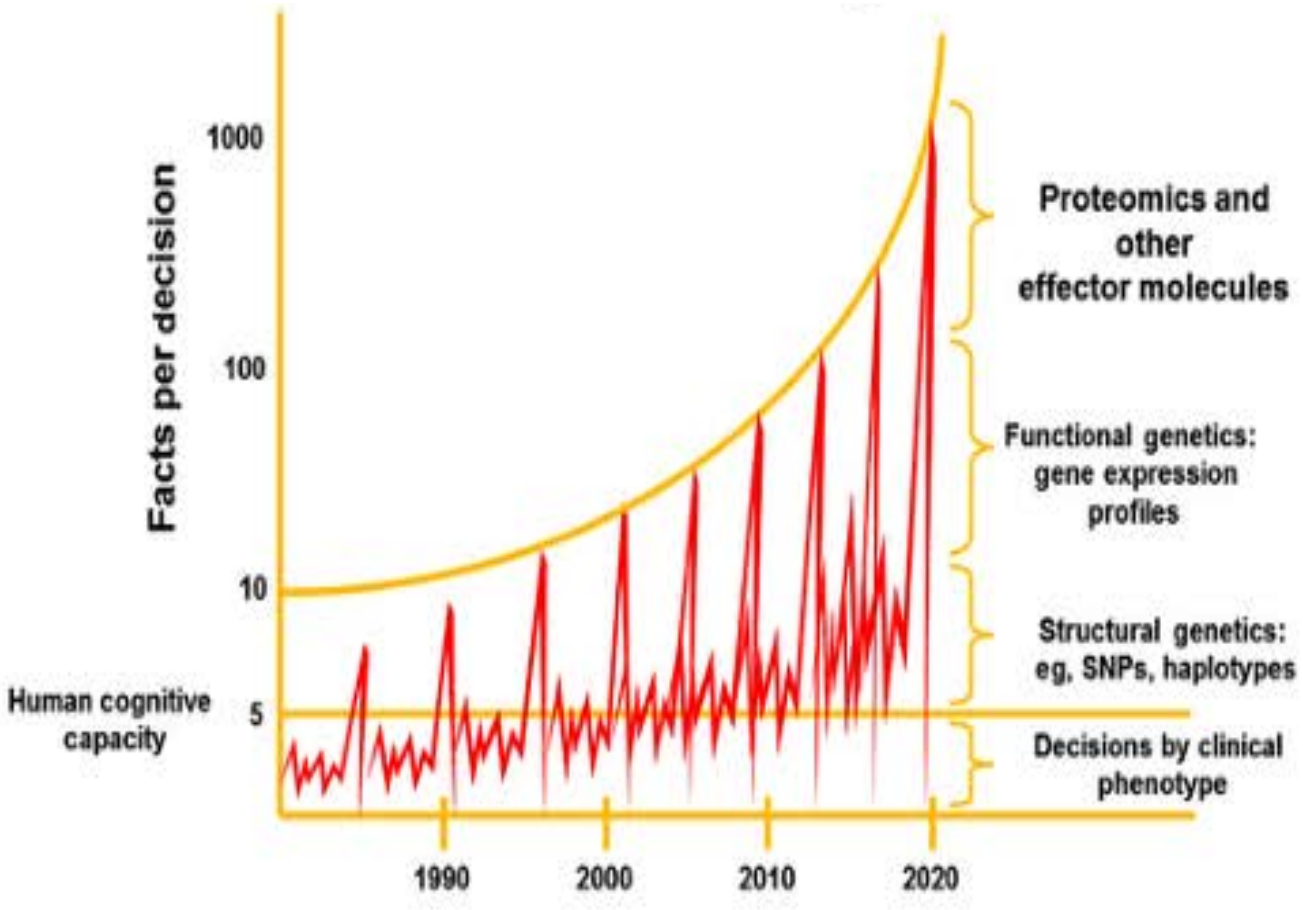
Chinese robot becomes world's first machine to pass medical exam

By Ma Si and Cheng Yu | chinadaily.com.cn | Updated: 2017-11-10 15:32

iFlytek's AI-enabled robot sits the test of China's national medical licensing examination. [Photo provided to China Daily]

Before a patient sees the doctor

Conclusion
- Human Technology Integration



Growth in facts affecting provider decisions over time juxtaposed against human cognitive capacity.

- Knowledge and Process in Technology
- Increasing exponentially
- Informatics, Data Science, and AI

- Knowledge and Process in Brain
- Unchanged
- Cognitive Science

(Graph is from William Stead)

Thank you!

At UTHealth School of Biomedical Informatics,

We Are