ASU Complex Adaptive Systems Initiative
Arizona State University

Stanford HEALTH CARE
STANFORD MEDICINE

The Strategic Landscape for the US Health Ecosystem: Challenges and Opportunities

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EMED 227/127 Health Care Leadership
Stanford University School of Medicine
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Observations on Leadership: Multi-Sector Career Experience

Academia

Imperial College London · University at Buffalo, The State University of New York · Penn, University of Pennsylvania · ASU · The University of Arizona

Industry

SmithKline Beecham · gsk GlaxoSmithKline · illumina · ORCHID · iNanoBio · CARIS Life Sciences · EXELIXIS

Government

Department of Defense · DTRA Defense Threat Reduction Agency – Detect. Deter. Defeat. · U.S. Department of Heath and Human Services · Central Intelligence Agency

Public Policy

The Royal Society · National Academy of Medicine · National Academy of Engineering · National Academy of Sciences · NASA · Hoover Institution · Bipartisan Commission on Biodefense

Professional

The Royal Society · The Academy of Medical Sciences · The Royal College of Pathologists – Pathology: the science behind the cure · Council on Foreign Relations · AIMBE American Institute for Medical and Biological Engineering
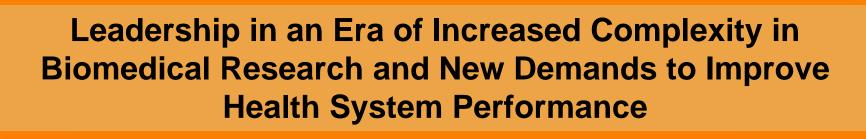
Leadership

- **identify and implement the organizational and functional skills needed to achieve strategic aspirations, operational goals and superior performance**

- **understand the network of key internal and external participants and systems that will enable or impede success**

- **promote and constantly adapt organizational competencies to respond to new challenges and opportunities**

- **every sector presents unique leadership challenges**

Leadership

- insatiable intellectual curiosity and work intensity
- talent selection, mentoring and celebrate the career advancement of colleagues
- open debate of best approaches to complex problems, particularly those with no precedent
- credit others (and always say 'thank you')
- no BS: willingness to say, "I don't know (but I'll find out)"
- accountability is not a dirty word
- humor helps!
- epitomize the ethos/ethic of the desired organizational culture and reputation

Leadership

- **relentless proactive evaluation of risks and opportunities in an era of accelerating change**
- **timely identification of emerging disruptive trends**
  - **cross-domain technology convergence and cross- sector private sector alliances**
- **agile decision making in the face of escalating complexity and uncertainty**

Leadership in an Era of Increased Complexity in Biomedical Research and New Demands to Improve Health System Performance

The US Healthcare Ecosystem

- the $4.1 trillion US health system (c. 20% GDP) is unmatched in the scale and diversity of organizations and functions

- over 450,000 entities involved in the development and delivery of highly specialized services to heterogenous populations over their lifetimes

- health ranks highest in public and political expectations regarding access, availability and affordability of care
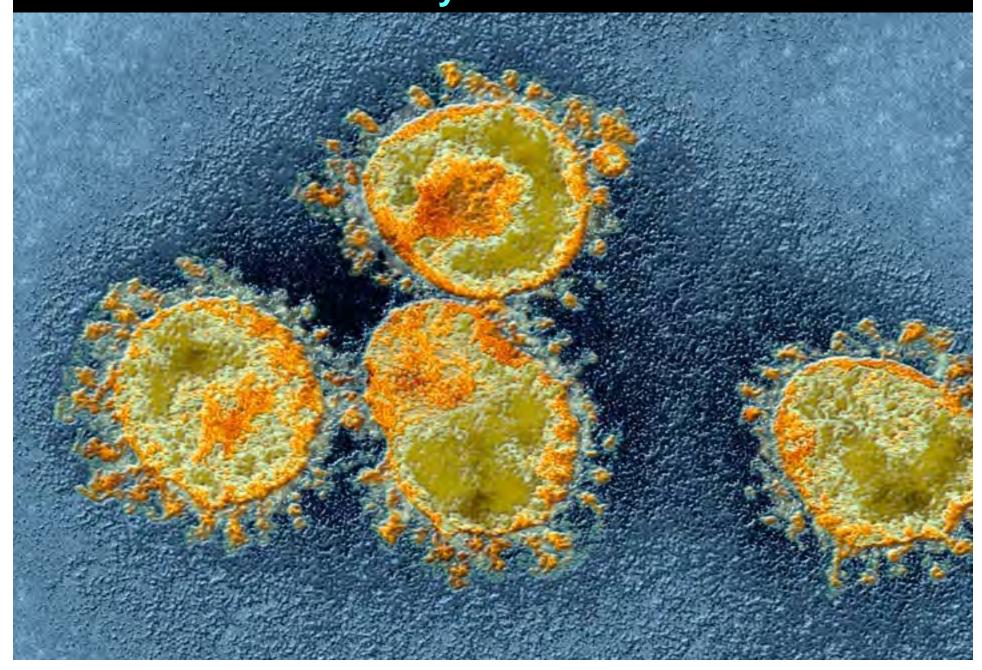
The US Health Ecosystem
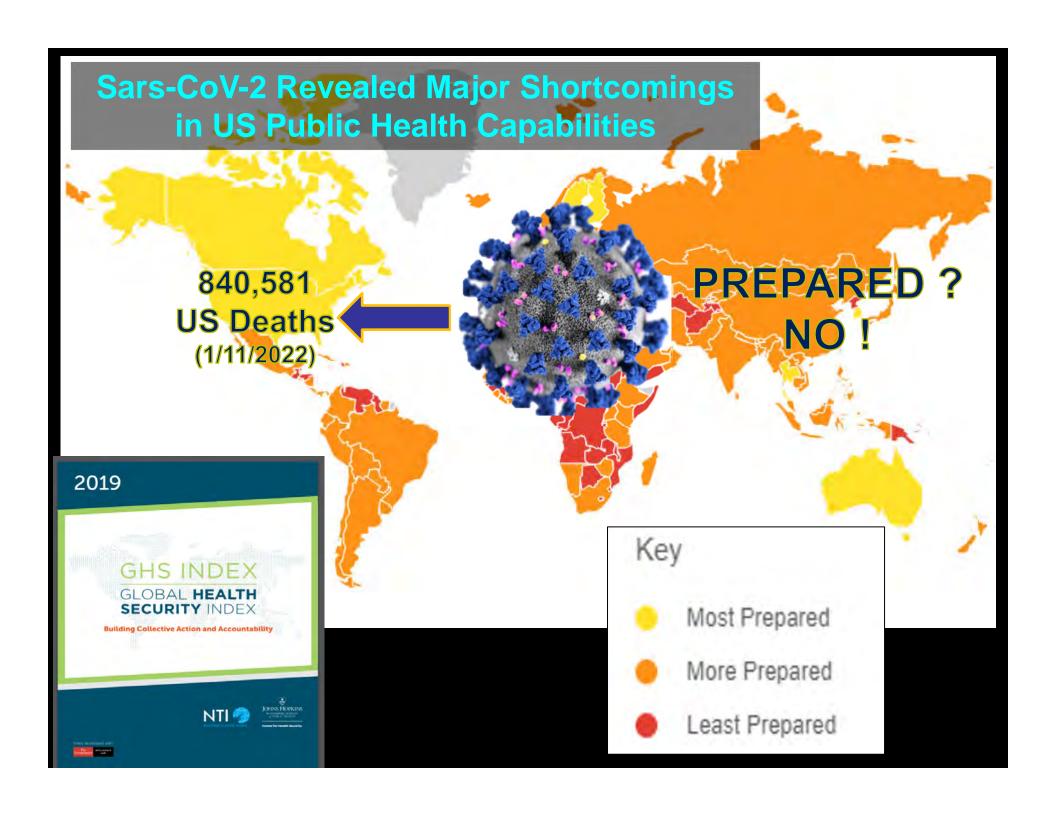
- economically and clinically unsustainable
- domination of care-centric activities (sick care) versus investment in health risk reduction (wellness)
- demographics of an aging society and increased chronic disease burden
    - 50% cost incurred in last six months of life
- disturbing increase in mental illness, SUD, suicide even before the COVID pandemic
- large disparities in access to care and wide variation in clinical practice
- poor coordination and continuity of care across the health/health care system
- inefficient integration and analysis of data to drive evidence-based/best practice protocols

The US Health Ecosystem

- **urgent imperative to increase access to care, reduce cost and improve clinical outcomes**
- **adoption of new systems-based approaches to identify and mitigate disease risk**
- **need for greater recognition of social determinants of health (SDoH) in disease risk and access/cost of care**
- **system fragility**
  - **lack of preparedness/resiliency for unanticipated large-scale disruption (pandemic, cyber, grid collapse, supply chains)**

A World Transformed By SARS-CoV-2

Sars-CoV-2 Revealed Major Shortcomings in US Public Health Capabilities

840,581 US Deaths (1/11/2022)

PREPARED ? NO !

2019

GHS INDEX

GLOBAL HEALTH SECURITY INDEX

Building Collective Action and Accountability

NTI   JOHNS HOPKINS
Center for Health Security

Key

Most Prepared

More Prepared

Least Prepared

A Report Card on US Response to COVID-19

Function	Grade
biosurveillance and proactive detection	D
rapid mobilization of case detection/contact tracing	F
supply chain for PPE/support resources	D
national coordination plan	F
fact-based communication and consistent messaging	F
politicization and social tensions	F
trust in government	D
accountability of decision makers	F

A Report Card on US Response to COVID-19

Function	Grade
biosurveillance and proactive detection	D
rapid mobilization of case detection/contact	F

Operation Warp Speed: Grade A+
Generation of Novel Vaccines at Unprecedented Speed.

Function	Grade
fact-based communication and consistent messaging	F
politicization and social tensions	F
trust in government	D
accountability of decision makers	F

The Commitment and Resiliency of Front-Line Personnel: Pre-Vaccine Risk Exposure in Healthcare Delivery

first responders

military services

ICU's

clinical laboratories

waste disposal

burn-out
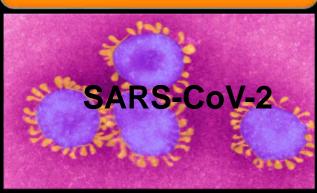
The Relentless Ever-Changing Dynamics of Infectious Diseases

old foes resurgent: Rx – resistance

traditional pandemic threats
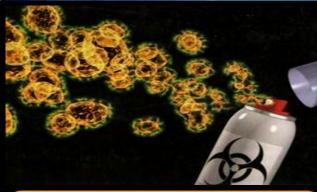
new foes: emerging infectious diseases

H1N1 FLU

SARS-CoV-2

climate change and new vector ranges

bioterrorism and bioweapons

dual-use research of concern and threat expansion

Biosecurity

- **imperative to rebuild comprehensive global surveillance and preparedness for known and future pandemic threats from emerging infectious diseases**

- **new dual-use technologies an expanded biothreat spectrum**
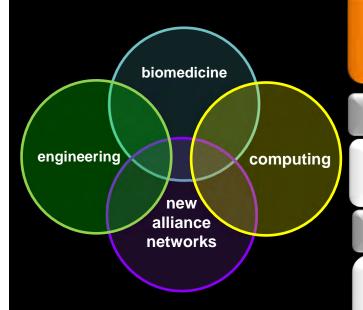
Precision Health and Digital Health: Inter-dependent Strategic Drivers in the Evolution of Healthcare Policies and Priorities

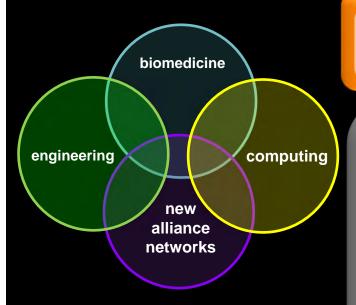The Strategic Landscape for the US Health Ecosystem

The Strategic Landscape for Biomedical Research and Health Services

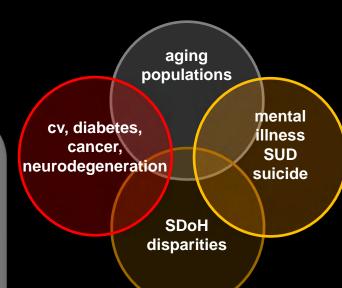**technology convergence and cross-disciplinary/ cross-sector networks**

more proficient use of data
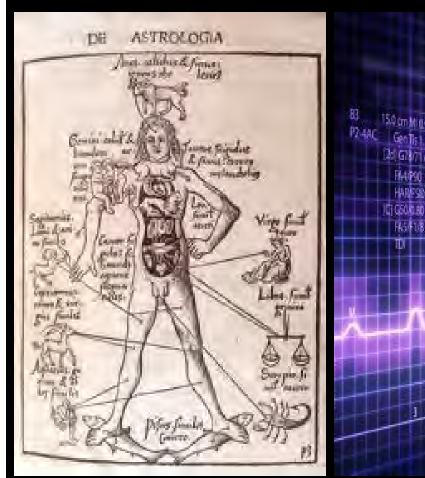
escalating burden of chronic disease

- biomedicine
- engineering
- computing
- new alliance networks

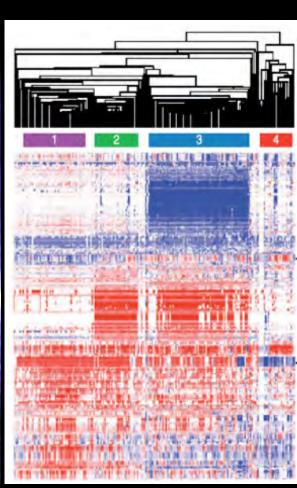**risk management of major cost drivers**

- **remote health monitoring to identify/mitigate risk**
- **reduce (re)hospitalization**
- **the expanded care space and continuity of care**
- **SDoH and health disparities**
- **predictive data analytics for at risk patients**

- aging populations
- cv, diabetes, cancer, neurodegeneration
- mental illness SUD suicide
- SDoH disparities

The Path to Precision Health:
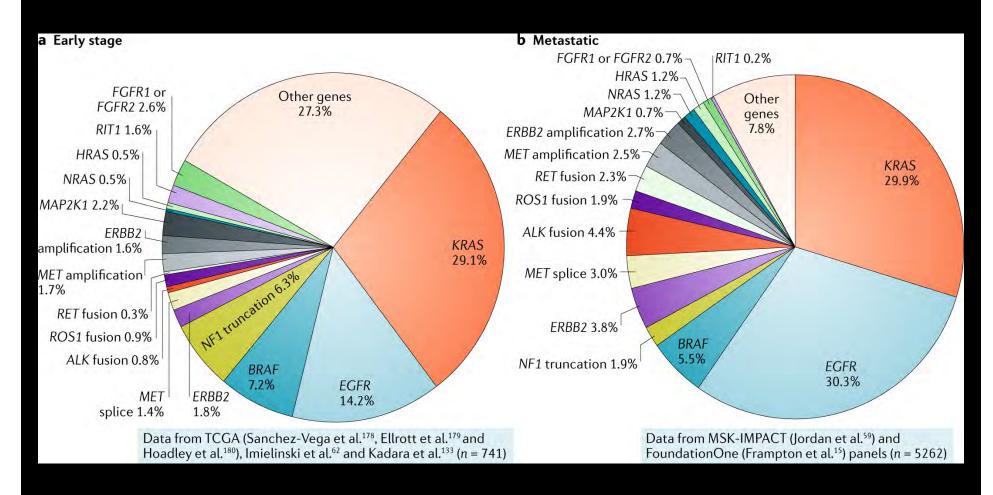# From Superstitions to Symptoms to (Molecular) Signatures

| humors; astrology, shamanism, sin and divine fate | biochemistry and organ-based pathophysiology | molecular biology and multi-omics profiling |

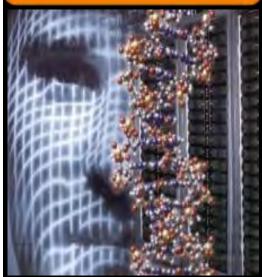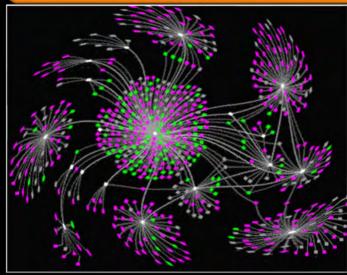# Molecular Classification of NSCLC and Identification of Single, Largely Non-Overlapping Oncogenic Alterations

a Early stage

FGFR1 or FGFR2 2.6%
RIT1 1.6%
HRAS 0.5%
NRAS 0.5%
MAP2K1 2.2%
ERBB2 amplification 1.6%
MET amplification 1.7%
RET fusion 0.3%
ROS1 fusion 0.9%
ALK fusion 0.8%
MET splice 1.4%
ERBB2 1.8%
BRAF 7.2%
EGFR 14.2%
NF1 truncation 6.3%
KRAS 29.1%
Other genes 27.3%

Data from TCGA (Sanchez-Vega et al.[178], Ellrott et al.[179] and Hoadley et al.[180]), Imielinski et al.[62] and Kadara et al.[133] (n = 741)

b Metastatic

FGFR1 or FGFR2 0.7%
RIT1 0.2%
HRAS 1.2%
NRAS 1.2%
MAP2K1 0.7%
ERBB2 amplification 2.7%
MET amplification 2.5%
RET fusion 2.3%
ROS1 fusion 1.9%
ALK fusion 4.4%
MET splice 3.0%
ERBB2 3.8%
NF1 truncation 1.9%
BRAF 5.5%
EGFR 30.3%
KRAS 29.9%
Other genes 7.8%

Data from MSK-IMPACT (Jordan et al.[59]) and FoundationOne (Frampton et al.[15]) panels (n = 5262)

From: F. S. Koulidis and J. V. Heymach (2019) Nature Rev. Cancer 19, 495

Precision Health

(Epi)Genomics and MultiOmics Profiling

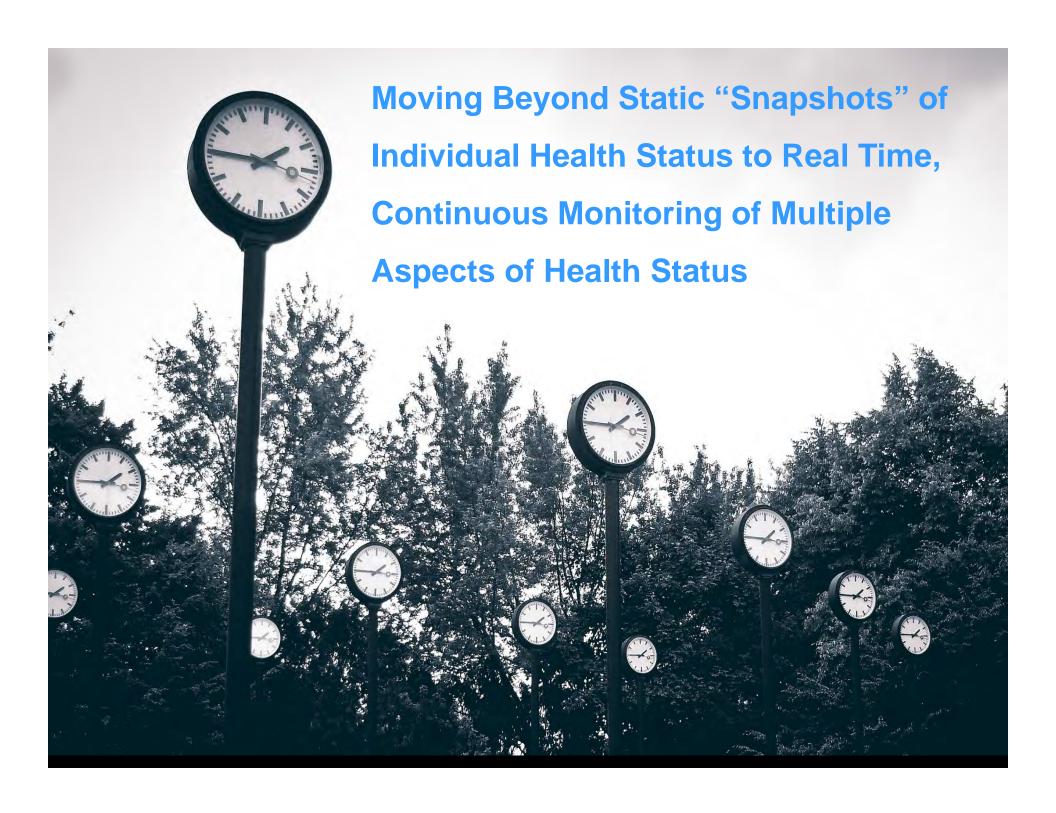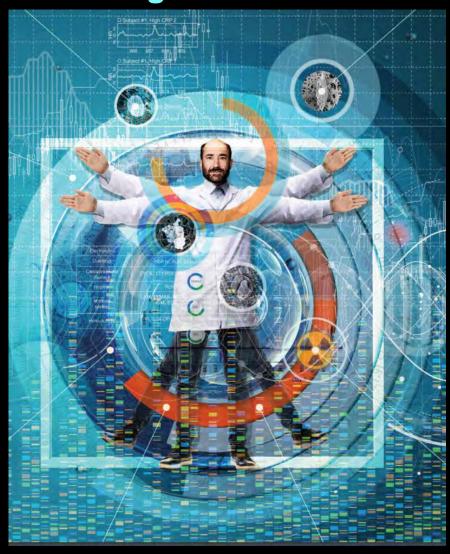**Detection of Altered Molecular Signaling Networks in Disease: A New Taxonomy of Disease and Subtype Classification**

- **terabytes per individual**
- **zettabyte – yottabyte population databases**

MDx Signatures of Disease Predisposition and Subtyping of Overt Disease for Optimum Rx Selection

The Challenge of Big (Messy) Data

Moving Beyond Static "Snapshots" of Individual Health Status to Real Time, Continuous Monitoring of Multiple Aspects of Health Status

Professor M. Snyder, Stanford University
A Prototypic Example of Comprehensive Multiparameter Profiling of Health Status
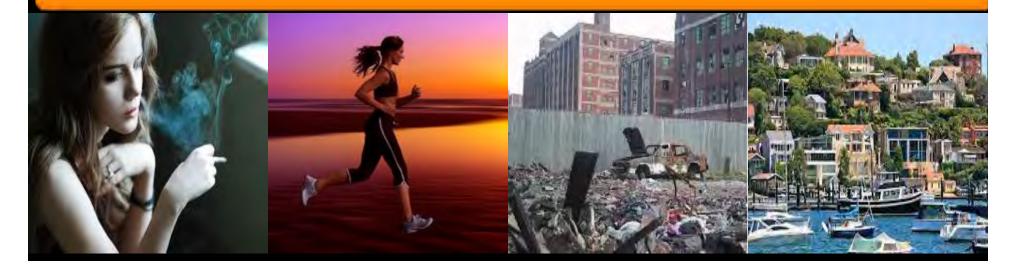

The Measures of A Man. 2021, December. Stanford Magazine, 34-40.

Deep Phenotyping:
"Much More Than Omics"- Overcoming the Curse of Reductionism

From Womb to Tomb: Systematic Integration of Diverse Health Data

SDoH, Lifestyle, Environment, Health Disparities

Precision Health and Digital Health: Evolving Inter-Dependencies

Individual Data

Population Databanks

integration and analysis of large scale (petabyte, exabyte) diverse data classes

Deep Phenotyping:

- multiOmics
- clinical history- EHR/PHR
- remote health monitoring
- socio-behavioral data
- environmental exposures

Building Personalized 'Digital Twins': Matching Individual Deep Phenotypes to 'Best Fit' Cohorts

Individual Data

Population Databanks

- 'digital twins and siblings' and imputed phenotypes
- disease predisposition and prevention
- earlier detection of subclinical disease and intervention
- selection of optimum treatment regimen for overt disease
- improved outcomes and QOL

Precision Health and Digital Health

Expanding 'The Care Space'
in Health and Illness

Monitoring Health Beyond the Clinic

Telemedicine and Remote Health Monitoring(RHM)

- **the majority of events that influence wellness/disease risk and treatment adherence occur largely outside of formal interactions with the healthcare system**

- **daily decisions by individuals have greater effects on their health than decisions controlled by the healthcare system**

Social Spaces Become Quantifiable

- **who knows why people do what they do?**
  - **the fact is that they do!**

- **these actions can now be traced and measured with unprecedented precision**

- **with sufficient data, the numbers reveal increasingly predictable behavior and individual risk patterns**

- **the confessional of social media**

- **the blurring of private and public spaces**

- **complex ethical and legal issues**
  - consent, privacy, security, surveillance

Wearables, Sensors, Mobile Devices and New Patient-Centric Delivery Channels

- better real time patient-specific data and decision-support tools

- each individual becomes their own control

- new patterns (touch points) of patient engagement with the health system

  - external reach and continuity in care

  - new delivery channels and services

  - targeted care and ability to monitor larger number of patients
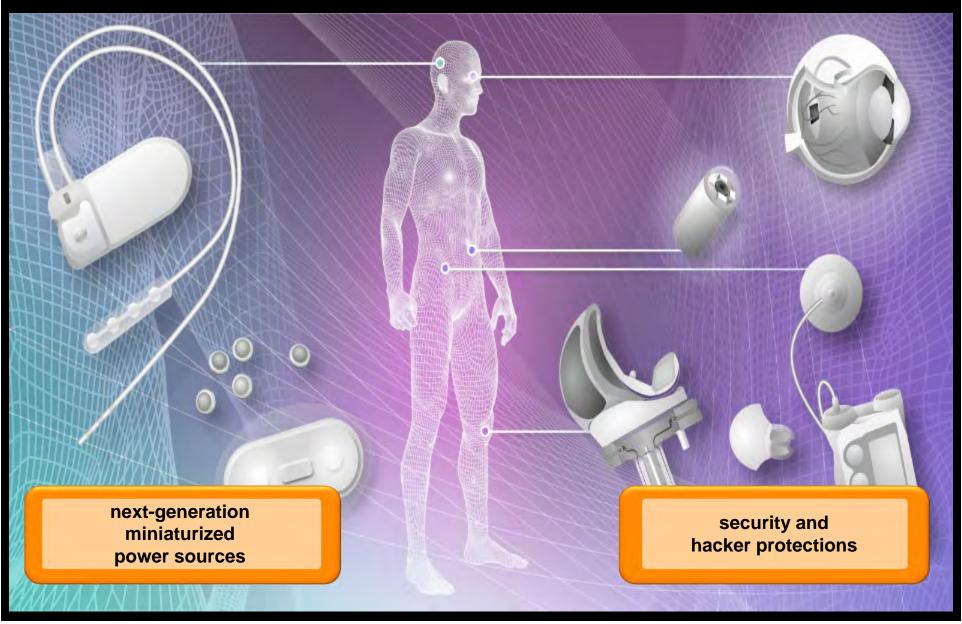
Wellness Apps for Fitness, Diet and Exercise

Remote Monitoring of Health Status

Implantable Devices and Wireless Monitoring (and Modulation)

next-generation miniaturized power sources

security and hacker protections

Smart Devices for Automated Drug Delivery and Improved Therapeutic Adherence

Propeller Health

Gecko (now Teva)

CapMedic

Biocorp Inspair

Help patients get *onboard* with *onbody* injections

Onbody Trainers
Device Replication
Actuation Simulation
Cartridge Simulation
Replaceable Device Adhesives
Injection Speed Simulation

noble | ONBODY TRAINING KIT

FOR TRAINING PURPOSES ONLY

noble® | Find out how a Noble onbody trainer can improve patient onboarding and boost your platform's competitive edge.

Contact us today 888.933.5646 or GoNoble.com/Onbody

Aterica
Veta
EpiPen

The SARS-CoV-2 Pandemic:
Accelerated Adoption of Telehealth Services

The SARS-CoV-2 Pandemic:
Accelerated Adoption of Telehealth Services

- **digital social distancing**

- **high receptivity by both health professionals and patients/caregivers**

- **relaxation of legislative constraints on reimbursement for virtual versus in-person visits and asynchronous diagnosis/treatment consults**

- **major infusion of venture capital into new telehealth companies and corporate M&A**

- **irreversible change in patterns of primary health care and behavioral health consultations?**

Networked Telehealth Between Provider Organizations

- **Centralized 24/7 Monitoring of Multiple Critical Care Units**

- **Peer to Peer Consultations**
- **Expanded Access to Subject Experts**

Economies of Scale, Convenience and Improved User Experience

Big Tech and Health Services: Disruptions Ahead?

Telehealth, RPM, PRO and the Growth of Decentralized Clinical Trials

Empowered Patients:
Social Networking Sites and Their Role in Clinical Care

- logical extension of the rapid rise of web/apps in mainstream culture to healthcare

- increasingly proactive and engaged consumers/patients/families

- greater access to information on treatment options, cost and provider performance

- new clinical practice tools to optimize physician-patient relationships

- Ux and formation of senior executive level Chief Patient Experience Officer posts in large provider organizations

The Growing Clinical and Economic Burden of Chronic Disease

Defining "Value" in Healthcare Will Intensify

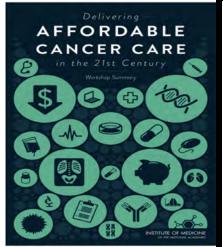# Medicare limits coverage of $28,000-a-year Alzheimer's drug

For Medicare to pay, patients will have to be part of clinical trials to assess Aduhelm's effectiveness against early-stage dementia and its safety.
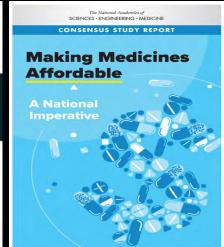
NCD Decision 1/11/2022

Defining "Value" in Healthcare Will Intensify

- improve clinical outcomes and QOL
  - QALY, DALY
  - socio-economic metrics: faster return to workplace/school
  - reduced demands and dependency on other societal support services
- new tools for 'downstream' future cost/benefit analysis
  - reduce demand for future resource use

Cancer Treatment Cost

Delivering **AFFORDABLE CANCER CARE** *in the 21st Century* — Workshop Summary — INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES

The Costs of Cancer — Addressing Patient Costs — Cancer Action Network

Promoting Value, Affordability, and Innovation in Cancer Drug Treatment — A Report to the President of the United States from the President's Cancer Panel

The National Academies of SCIENCES · ENGINEERING · MEDICINE — **CONSENSUS STUDY REPORT** — **Making Medicines Affordable** — **A National Imperative**

Value Framework

ASCO®

ESMO

ICER — INSTITUTE FOR CLINICAL AND ECONOMIC REVIEW

DrugPricing Lab — Memorial Sloan Kettering

Cost vs. Value and the Price of Innovation in Cancer Care: Oral Anticancer Drugs in Multiple Myeloma, as a Case Study — GOLDWATER INSTITUTE — March 28, 2018
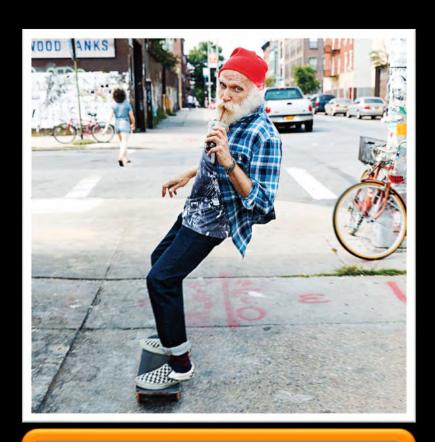
Why Should Price Vary With Location?

- **price for oncology drugs administered in hospital versus typically double price paid for community clinic**
- **Herceptin**
  - **hospital/hospital outpatient $5,350**
  - **independent clinic $2,740**
- **Avastin**
  - **clinic ($6,620), hospital ($14,100)**
- **incentive for trend for purchase of community clinics by hospital systems and reclassification as 'hospital outpatient clinics' and eligible for 340B discounts**

The Demographics of an Aging Society: Clinical and Economic Challenges to U.S. Healthcare

wellness with longevity and high QOL

OR

multiple co-morbidities and low QOL

?   ?

Reducing Hospital Readmissions

- **identification and focus on higher-risk, higher-complexity patient**

- **patient coaching/education on discharge instructions and self-management**

- **adherence to complex polypharmacy**

- **engage family members**

- **use of transitional care nurses and other care coordination professionals**

Grey Technologies and Ageing in Place:
Independent But Monitored Living for Ageing Populations

Rx adherence

cognitive stimulation

in-home support and reduced readmissions

reduced office visits

Chatbots and Support Robots in Healthcare

Amazon and Home Care

Development of Third-Party Alexa Apps

LIFE | HEALTH | FREEDOM
LIBERTANA®

Allows seniors to verbally report medical data, get exercise and adherence reminders, call a caregiver, and coordinate transport

MAYO CLINIC

Mayo Clinic First Aid

"Tell me about spider bites"   "Help for a burn"

Ask My Buddy

"Alexa, ask My Buddy to alert everyone."

Telemedicine and Behavioral Health: Digital Psychiatry and Non-Pharmacologic Digital Therapeutics
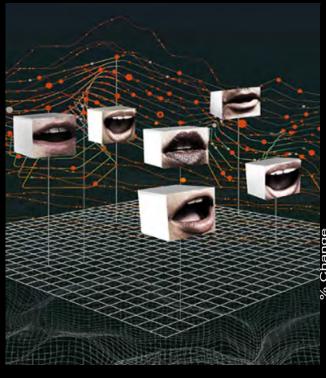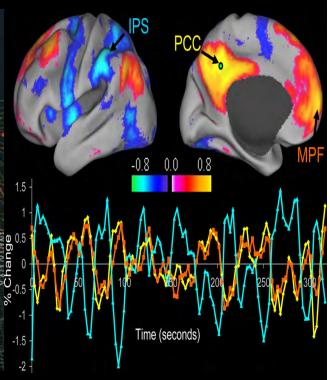
Increased ED Behavioral Health Emergencies

- reported range of 8-25% of ED volume (outliers higher)
- 70% of behavioral health patients also have one or more co-morbidities
- opioid-related visits tripled between 2005-19
- approx. 1 in 4 individuals with serious mental illness also have substance abuse disorder
- 60% of adolescents in community-based SUD treatment programs also meet diagnostic criteria for mental illness
- dramatic increase in mental health needs in COVID-19 pandemic

Digital Psychometrics and Evaluation of Mental Illness

- eye micro saccades
- facial dynamics
- stimulus response and interaction speeds

- speech patterns (rhythm, tone, volume)
- semantic construction

- brain imaging functional MRI
- altered signal pathways

Digital Psychometrics and Mental Illness

- interaction with digital assistants/chatbots

- machine learning and AI analytics of large video banks and social media posts

  - bipolar disorder, schizophrenia, depression

  - suicidal ideation

  - PTSD

- alerts to care teams when immediate intervention indicated

Robotics and Human-Machine Interactions

Brain-Machine Interface Technologies and Augmented Sensory, Motor and Cognitive Functions

Robotic Assist Systems and Exoskeletons for Rehabilitation

Robot–Human Directed Interactions

Co-evolution of Human-Machine Interactions, Robotics and Augmented Cognition

VR/AR/MR and Preparation for Complex Procedures

VR/AR and Neuromodulation

- **promote behavior change via altered sensory inputs and feedback**

- **mental illness: PTSD, physical rehabilitation, substance abuse and pain control**

The Metaverse, Avatar Worlds and Immersive Sensory Technologies

- **substantial opportunities for health education and training**

BUT

- **critical need for proactive development of oversight of applications in healthcare to avoid a dystopian déjà vu of social media disinformation and psychological manipulation**

Now Comes the Hard Part!

Driving Precision Health and Large Scale Data Analytics into Routine Practice

New Incentives and New Delivery Models

New Participants and New Business Models

HELL IS THE PLACE WHERE NOTHING CONNECTS — T.S. ELIOT

**Welcome to
The World of
Biomedical Research
and
Healthcare Information Systems**

Biomedical Data: Vast But Poorly Utilized

- **inadequate standardization**

- **fragmented, incomplete, inaccurate data and uncertain provenance**

- **incompatible data formats as barrier to data integration and sharing**

- **obstacles to EHR integration of new data classes (multi-Omics; wearables; IoMT)**

- **legislative barriers to data transfer based on well intentioned privacy protections (HIPAA)**

- **organizational, economic and cultural barriers to open data sharing**

- **static, episodic snap shots of complex dynamic systems**

- **major impediments to research productivity, optimum clinical decisions and continuity-of-care for patients**

Data Security and Protection of Health Information

**Big Tech: Big Provider Linkups
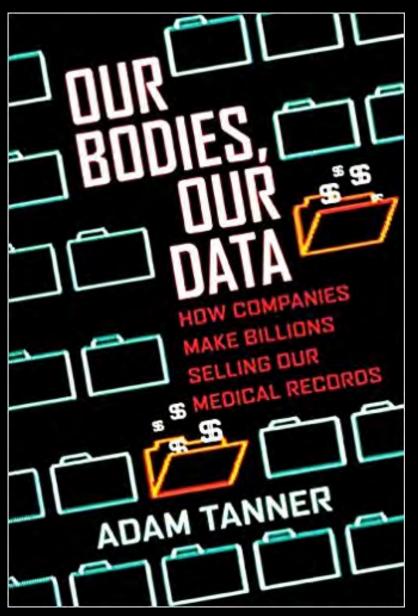Fuel HIPAA Privacy Debate**
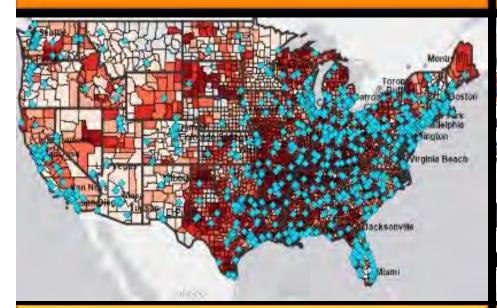
Health Data Brokers and 'Selling-On"

OUR BODIES, OUR DATA

HOW COMPANIES MAKE BILLIONS SELLING OUR MEDICAL RECORDS

ADAM TANNER

Bloomberg Businessweek
November 8, 2021

Your DNA

Big Pharma

23andMe

CEO Anne Wojcicki

The spit-tube startup wants to be a big-time drug company

National Security Implications of Genome Data on Populations

Population Databanks

Individual Profiles

Foreign Access to Data

Data Security

Technology Acceleration and Convergence:
The Escalating Challenge for Professional Competency, Decision-Support and Future Medical Education
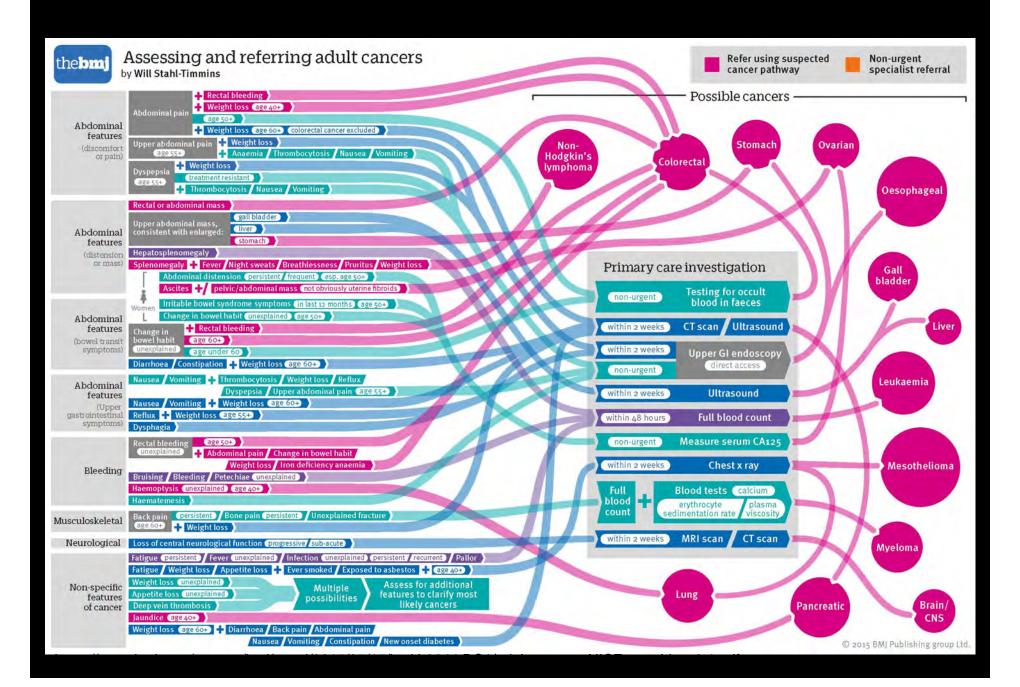
Data Deluge

Cognitive Bandwidth Limits

Automated Analytics and Decision Support

Facile Formats for Actionable Decisions

Assessing and referring adult cancers

the bmj

by Will Stahl-Timmins

Legend:
- ■ Refer using suspected cancer pathway
- ■ Non-urgent specialist referral

Possible cancers

Abdominal features (discomfort or pain)

Abdominal pain
- + Rectal bleeding
- + Weight loss (age 40+)
- (age 50+)
- + Weight loss (age 60+) (colorectal cancer excluded)

Upper abdominal pain (age 55+)
- + Weight loss
- + Anaemia / Thrombocytosis / Nausea / Vomiting

Dyspepsia (age 55+)
- + Weight loss
- treatment resistant
- + Thrombocytosis / Nausea / Vomiting

Abdominal features (distension or mass)

- Rectal or abdominal mass
- **Upper abdominal mass, consistent with enlarged:** gall bladder / liver / stomach
- Hepatosplenomegaly
- Splenomegaly + Fever / Night sweats / Breathlessness / Pruritus / Weight loss

Abdominal features (bowel transit symptoms)

Women
- Abdominal distension (persistent / frequent) (esp. age 50+)
- Ascites +/ pelvic/abdominal mass (not obviously uterine fibroids)
- Irritable bowel syndrome symptoms (in last 12 months) (age 50+)
- Change in bowel habit (unexplained) (age 50+)

Change in bowel habit (unexplained)
- + Rectal bleeding
- (age 60+)
- (age under 60)
- Diarrhoea / Constipation + Weight loss (age 60+)

Abdominal features (Upper gastrointestinal symptoms)

- Nausea / Vomiting + Thrombocytosis / Weight loss / Reflux
- Dyspepsia / Upper abdominal pain (age 55+)
- Nausea / Vomiting + Weight loss (age 60+)
- Reflux + Weight loss (age 55+)
- Dysphagia

Bleeding

- Rectal bleeding (age 50+) (unexplained)
- + Abdominal pain / Change in bowel habit
- Weight loss / Iron deficiency anaemia
- Bruising / Bleeding / Petechiae (unexplained)
- Haemoptysis (unexplained) (age 40+)
- Haematemesis

Musculoskeletal

- Back pain (age 60+) (persistent) / Bone pain (persistent) / Unexplained fracture
- + Weight loss

Neurological

- Loss of central neurological function (progressive / sub-acute)

Non-specific features of cancer

- Fatigue (persistent) / Fever (unexplained) / Infection (unexplained) (persistent / recurrent) / Pallor
- Fatigue / Weight loss / Appetite loss + Ever smoked / Exposed to asbestos + (age 40+)
- Weight loss (unexplained)
- Appetite loss (unexplained) — **Multiple possibilities** — **Assess for additional features to clarify most likely cancers**
- Deep vein thrombosis
- Jaundice (age 40+)
- Weight loss (age 60+) + Diarrhoea / Back pain / Abdominal pain
- Nausea / Vomiting / Constipation / New onset diabetes

Primary care investigation

- **non-urgent** — Testing for occult blood in faeces
- **within 2 weeks** — CT scan / Ultrasound
- **within 2 weeks** — Upper GI endoscopy (direct access)
- **non-urgent**
- **within 2 weeks** — Ultrasound
- **within 48 hours** — Full blood count
- **non-urgent** — Measure serum CA125
- **within 2 weeks** — Chest x ray
- **Full blood count** + Blood tests (calcium) / erythrocyte sedimentation rate / plasma viscosity
- **within 2 weeks** — MRI scan / CT scan

Possible cancers

- Non-Hodgkin's lymphoma
- Colorectal
- Stomach
- Ovarian
- Oesophageal
- Gall bladder
- Liver
- Leukaemia
- Mesothelioma
- Myeloma
- Lung
- Pancreatic
- Brain/CNS

The Emergence of Big Data Changes the Questions That Can Be Asked

Isolated Data

Complex Networked Data

Complex Computational Data

Automated Context: Data Finding Data "Intelligence at Ingestion"

Feature Extraction and Classification → **Context Analysis ⇅ Persistent Context** → • **Relevance Mapping** • **Learning Systems** → • **Situational Awareness** • **Rapid, Robust Decisions**
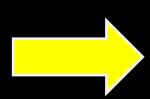
Precision Health and Digital Health: Building the Learning Health System

qualitative, descriptive information of variable quality and provenance → **quantitative data of known provenance and validated quality**

complex ecosystem of largely unconnected data sources → **evolving, inter-connected networks of data sources for robust decisions and improved care**

Machine Learning (ML) and Artificial Intelligence (AI) and the Analysis of Large Scale Heterogenous Health Data

The Future of 'Automated Search' and 'Retrieval'
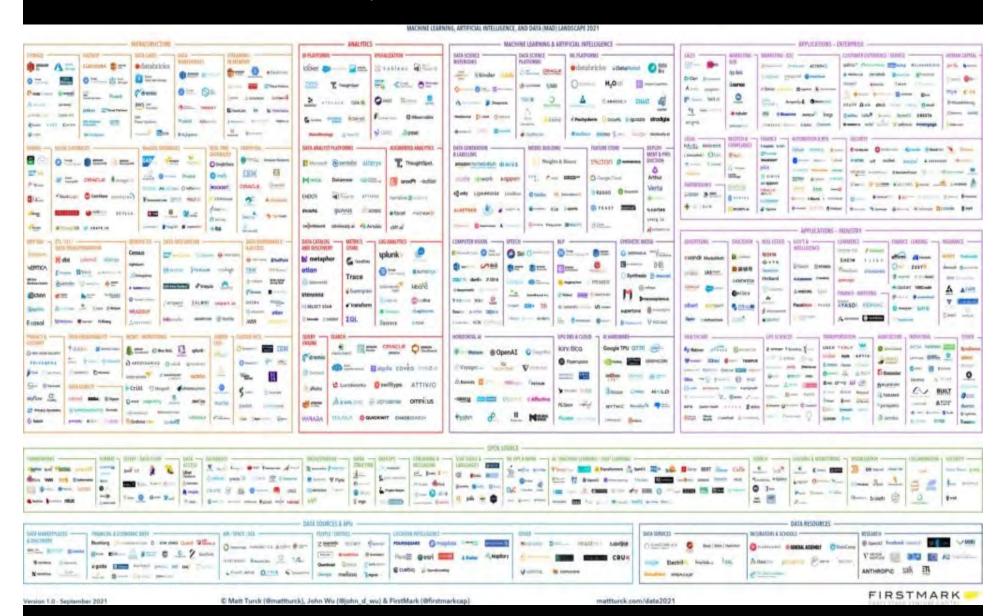
Deep Understanding of Content and Context

Collapse Time to Decision: Intelligence at Ingestion

**Automated and Proactive Analytics:
Why Wait for the Slow Brain to Catch Up to the Fast Machine**

MACHINE LEARNING, ARTIFICIAL INTELLIGENCE, AND DATA (MAD) LANDSCAPE 2021

Version 1.0 - September 2021

© Matt Turck (@mattturck), John Wu (@john_d_wu) & FirstMark (@firstmarkcap)

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FIRSTMARK
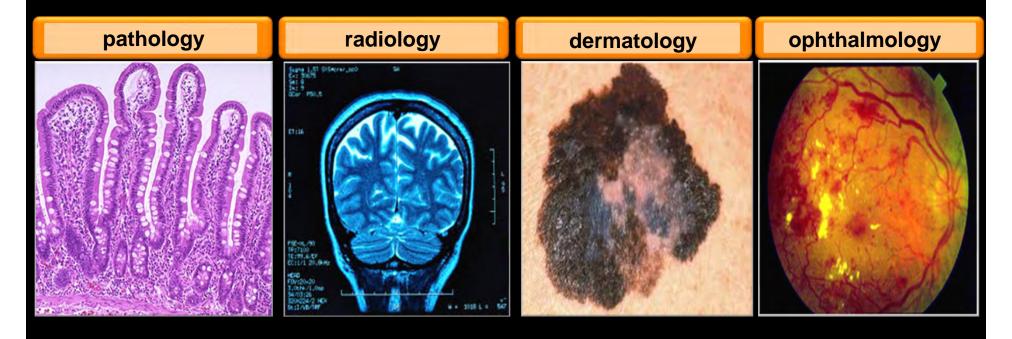
Just What the Data Ordered

Machine Intelligence and Algorithms for Clinical Diagnosis and Treatment Decisions
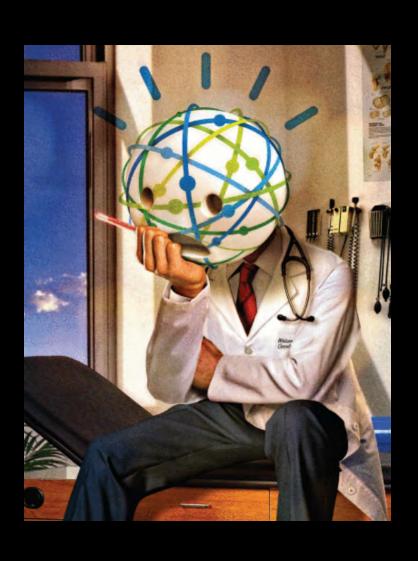
Black Box Medicine?

Machine Learning and Image Analysis in Clinical Medicine

pathology	radiology	dermatology	ophthalmology

- large scale training sets and classification parameters
- standardized, reproducible and scalable
- 260 million images/day for $1000 GPU

Bias: The Omnipresent Danger in ML/AL Datasets
IBM Watson and Cancer Care: A Classic Case Study

- **overpromised and underdelivered**
- **underpowered training sets**
- **institution-specific data and bias**
- **risk to patients**
- **instructive precedent for more stringent AI validation standards**

How Will ML-AI Algorithms/decision Analytics

Be Validated and Regulated?

- **how will regulators accommodate accelerating pace of changes in inputs, outputs and code construction in ML/AI algorithms (V_1, V_2, V_n….)?**

Machine Learning (ML), Artificial Intelligence (AI) and Healthcare

- **which clinical specialties/processes will be at risk of replacement by ML-AI and when?**

- **how will professional competencies in using ML-AI decision-support tools be developed and sustained?**

    - **MD curriculum, CME**

    - **non-medical data science professionals**

- **how will ML-AI platforms alter payment schemes ?**

- **what new malpractice liabilities will emerge by failure to use/interpret ML-AI platforms?**
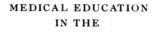
Living in a World Where the Data Analytics and Interpretation Algorithms Are Obscure to the End User

- ceding decision authority to computerized support systems

- culturally alien to professionals in their claimed expertise domain but they accept in all other aspects of their lives

- who will have the responsibility for validation and oversight of critical assumptions used in automated decision tools in healthcare?

  - regulatory agencies and professional societies?

  - humans?

  - machines?

"Digital Darwinism": A Looming Digital Divide

- understanding data structure and its productive application/customization to improve clinical decisions and care outcomes will become a critical institutional competency

- major skill gaps and personnel shortages in biomedicine

- training of a new cadre of data scientists (medical and non-medical)

- institutions lacking adequate computational infrastructure and critical mass in data analytics will suffer 'cognitive starvation' and relegation to competitive irrelevance

Major Transitions in Medical Education and Healthcare
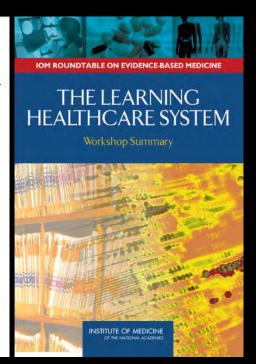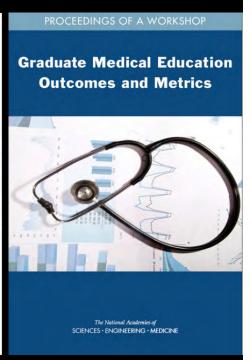
1910 - present

2000 - present
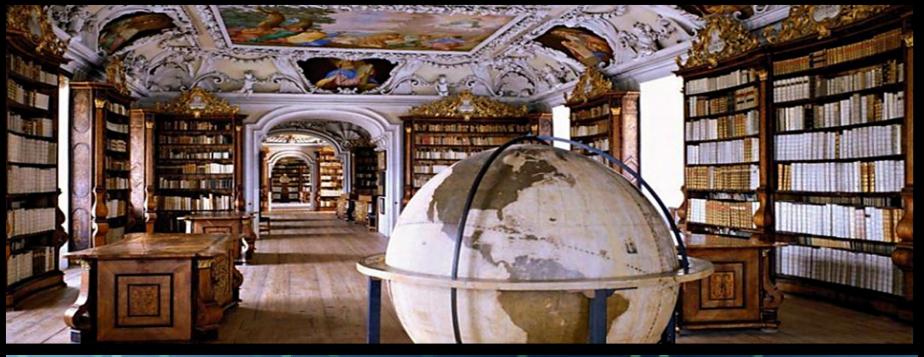
2015 - ?

(science-centric)

healthcare as a learning system (data-centric)

mastery of escalating complexity and massive data (network-centric)
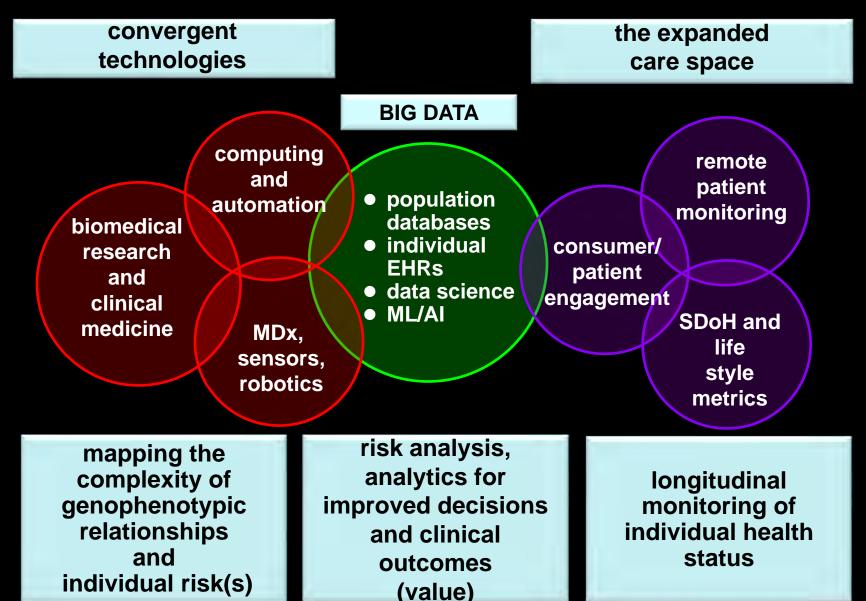
New Patterns of Learning
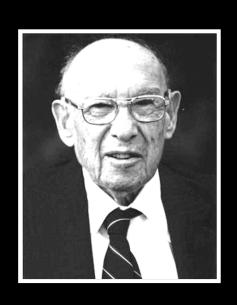
**Leadership in an Era of Accelerating Complexity and Uncertainty
in Biomedical Research and Demands to Improve Health System Performance**

The Co-Evolution of Precision Health, Digital Health and Learning Healthcare Information Systems

convergent technologies

the expanded care space

BIG DATA

biomedical research and clinical medicine

computing and automation

MDx, sensors, robotics

- population databases
- individual EHRs
- data science
- ML/AI

consumer/ patient engagement

remote patient monitoring

SDoH and life style metrics

mapping the complexity of genophenotypic relationships and individual risk(s)

risk analysis, analytics for improved decisions and clinical outcomes (value)

longitudinal monitoring of individual health status

Unidimensional "Quick Fixes"
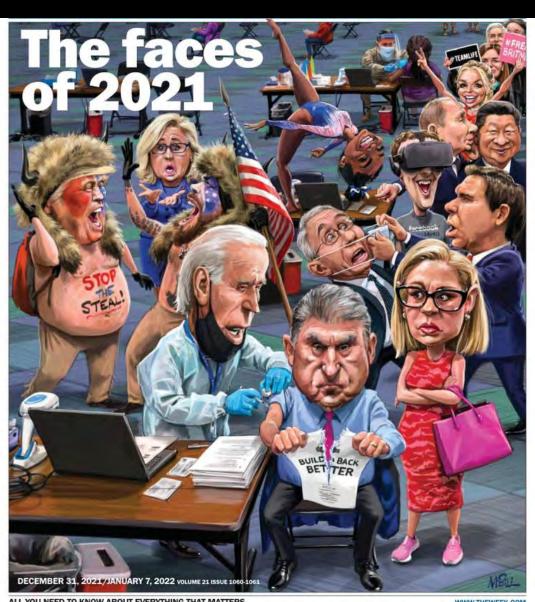
"The greatest danger in times of turbulence,
is not the turbulence,
it is to act with yesterday's logic."

- Peter Drucker

The Challenge of Charting Health Policy in a Climate of Increased Social Divisions

- **Dysfunctional National Governance, Lack of Bipartisanship and Legislative Paralysis**

- **Legislative Technical Illiteracy and the Retreat from Complexity**

- **Dangerous Societal Divisions on Multiple issues**

- **Implications Well Beyond Healthcare: A Threat to National Security and Technological Competitiveness ?**

The faces of 2021

STOP THE STEAL!

BUILD BACK BETTER

DECEMBER 31, 2021/JANUARY 7, 2022 VOLUME 21 ISSUE 1060-1061

ALL YOU NEED TO KNOW ABOUT EVERYTHING THAT MATTERS

WWW.THEWEEK.COM

The Principal Challenges Facing the US Health Ecosystem

- **the status quo is not sustainable**
  - **cost, outcomes, access, disparities**
- **silos subvert solutions**
  - **barriers to continuity of care, cost-effectiveness and reform**
- **imperative to rethink and redesign health ecosystem objectives, functions, capabilities and responsibilities**
- **widespread failure to apply systems-based analysis methods to optimize inter-dependencies and connectivities for value-based care both population and individual care services**

The

BRIDGE

LINKING ENGINEERING AND SOCIETY

NATIONAL ACADEMY OF ENGINEERING

https://www.nae.edu/File.aspx?id=244667

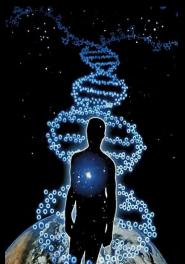# "Strategic Design Spaces for the Evolution of Health Care"

Precision Health Biotechnology, Synthetic Biology
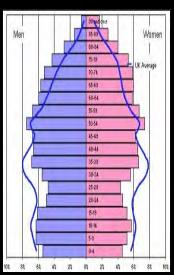
Population Demographics and Disease Burden

IoMT: Ubiquitous Sensing and Sensor Networks

Big Data Analytics, Machine Learning and AI

Technology Convergence, Acceleration and Escalating Complexity

"Bio-Space"

"Unmet Need Space"

"Connected and Monitored Space"

"Decision Space"

"Opportunity Space"

Improved Health Risk and Mitigation

Defining "Value" in Healthcare Will Intensify

New Knowledge Networks

New Participants

New Organizational Models

"Strategic Design Spaces for the Evolution of Health Care"
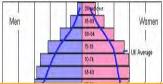
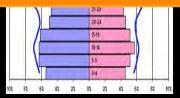| Precision Health Biotechnology, Synthetic Biology	Population Demographics and Disease Burden	IoMT: Ubiquitous Sensing and Sensor Networks	Big Data Analytics, Machine Learning and AI	Technology Convergence, Acceleration and Escalating Complexity

Slides available @ casi.asu.edu/presentations

"Bio-Space"	"Unmet Need Space"	"Connected and Monitored Space"	"Decision Space"	"Opportunity Space"

Improved Health Risk and Mitigation

Defining "Value" in Healthcare Will Intensify

New Knowledge Networks   **New Participants**   **New Organizational Models**