

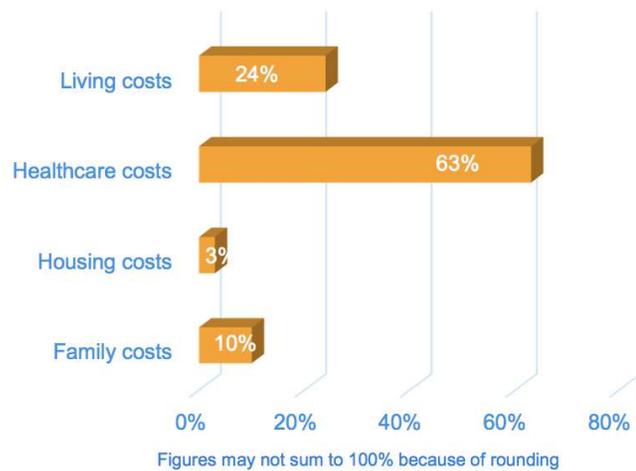
Framing Tech Trends in Healthcare

Bern Shen MD

SAS Health & Retirement Conference

Singapore - 11 Oct 2018

What's your biggest financial concern when planning for retirement?



- Healthcare costs were by far the biggest concern, with double the response of the second-most popular response
- This is likely to be reflective of respondents' awareness of the rapid escalation of healthcare claim incidence, claim costs and insurance premiums at older ages



Data (test)

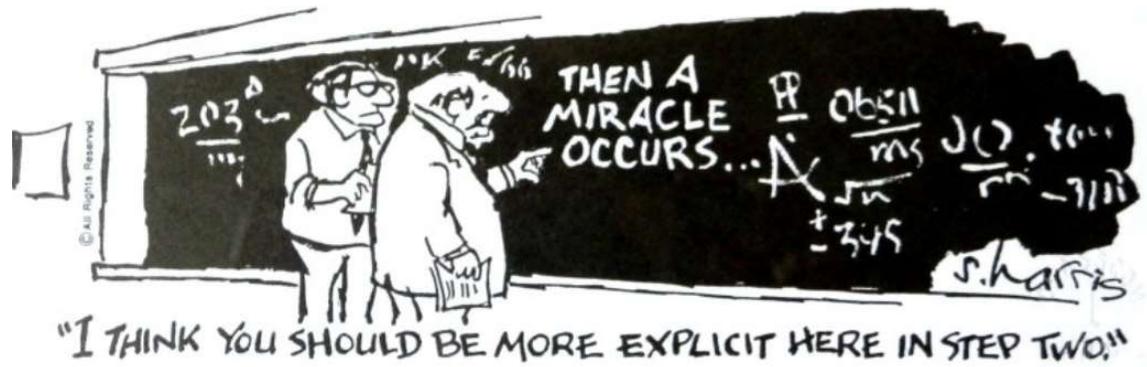
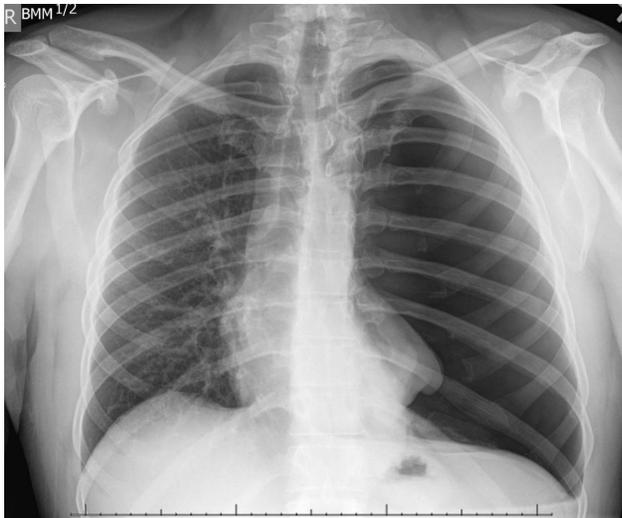
Insight (diagnose)

Action (treat)



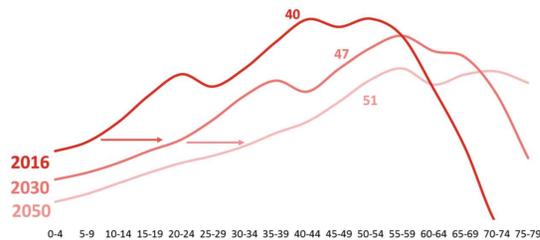
UPMC





Context

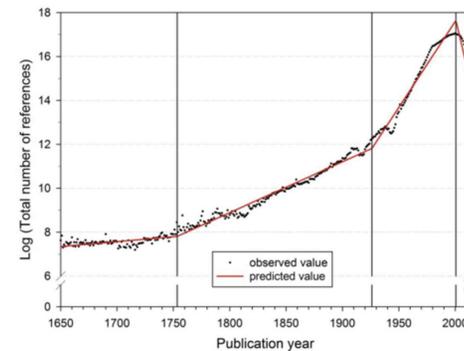
↑ Demand: Ageing population;
chronic, complex disease



Source: United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision.

Over 65 population will double by 2030 to 1 in 4 Singaporeans

↑ Supply: Rapid
technological evolution

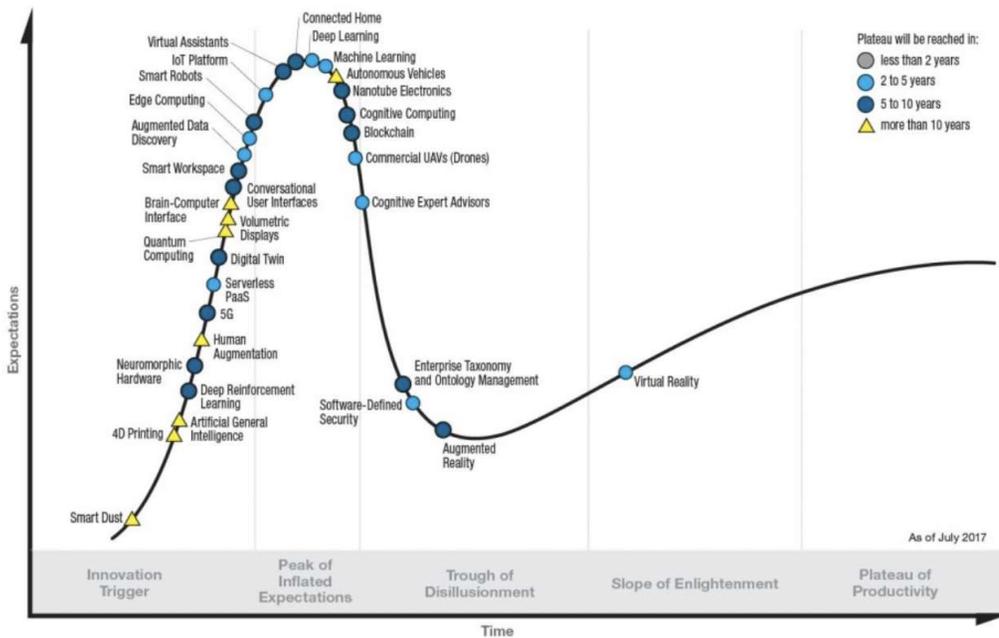


Global scientific output doubling roughly every 9 years

Data/decision overload

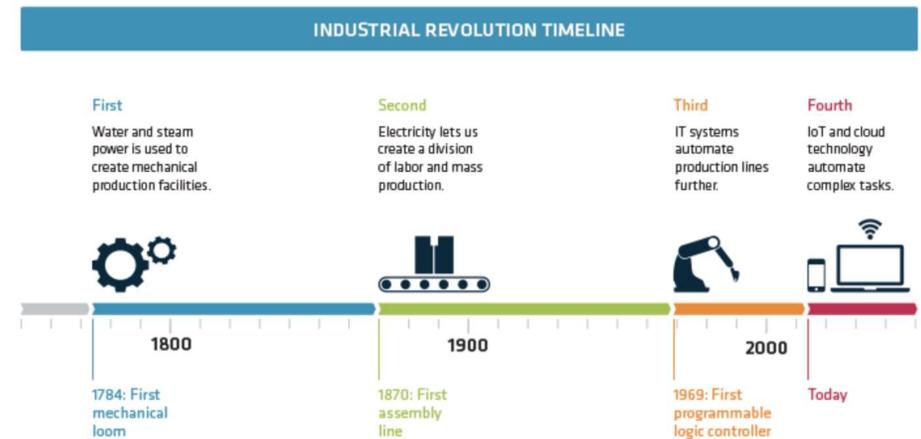
New technologies...

Gartner Hype Cycle for Emerging Technologies, 2017



“...fusion of technologies that is blurring the lines between the physical, digital, and biological spheres”

-- Klaus Schwab, World Economic Forum



<https://mjolner.dk/2015/01/14/realizing-the-fourth-industrial-revolution/>

Source: Gartner (July 2017)
© 2017 Gartner, Inc. and/or its affiliates. All rights reserved.

New risks

"We are building a civilization that is deeply connected yet technologically insecure... in other words, a world that is wired for crime."

- Unintentional:

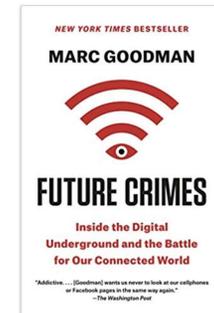
- 20-30 bugs per 1000 lines of code
- Component testing ≠ integration testing



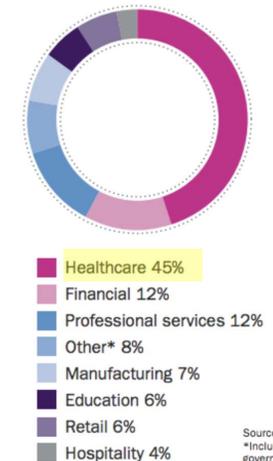
- Intentional:

- Ransomware: ~45% of attacks targeted healthcare
- Data breaches in 1H2018: ~2 million patients
- Oct 2018 KLAS report: 10,000 devices/enterprise, 1/3 "unpatchable"

Similar potential risks in medical devices, pharma, care delivery...



2017 ransomware incidents by industry



Source: BBR Services 2017
*Includes utilities, construction, government and real estate

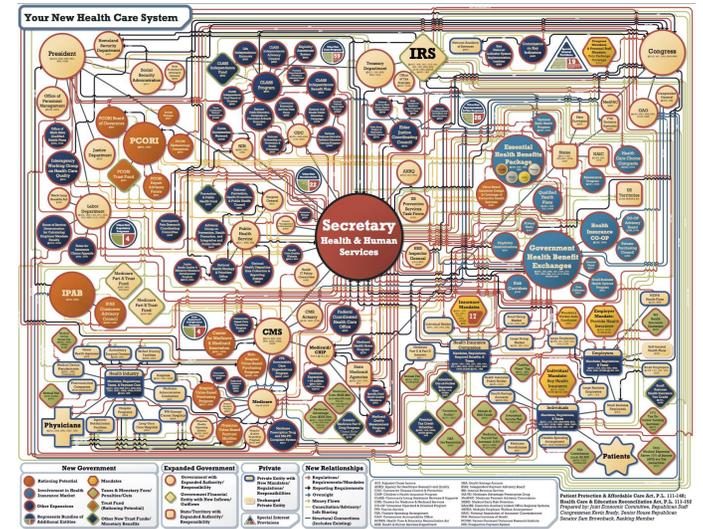
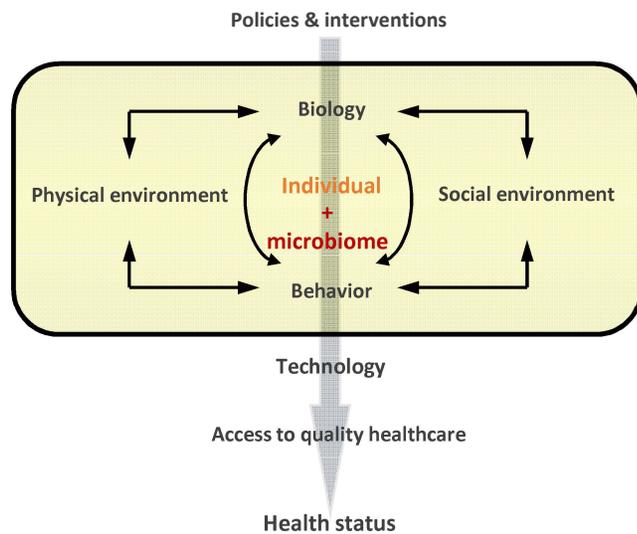
A broader lens (unit of analysis)

- From individuals → communities
- From diseases → disease networks
- From technical → sociotechnical

A broader lens (unit of analysis)

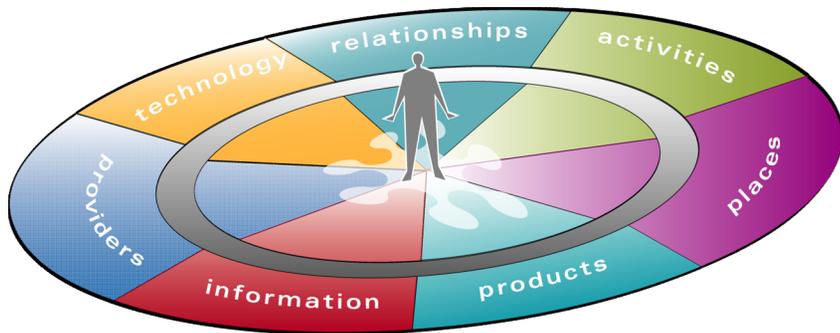
- From individuals → communities
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Individuals → communities



Adapted from Healthy People 2010

Individuals → communities



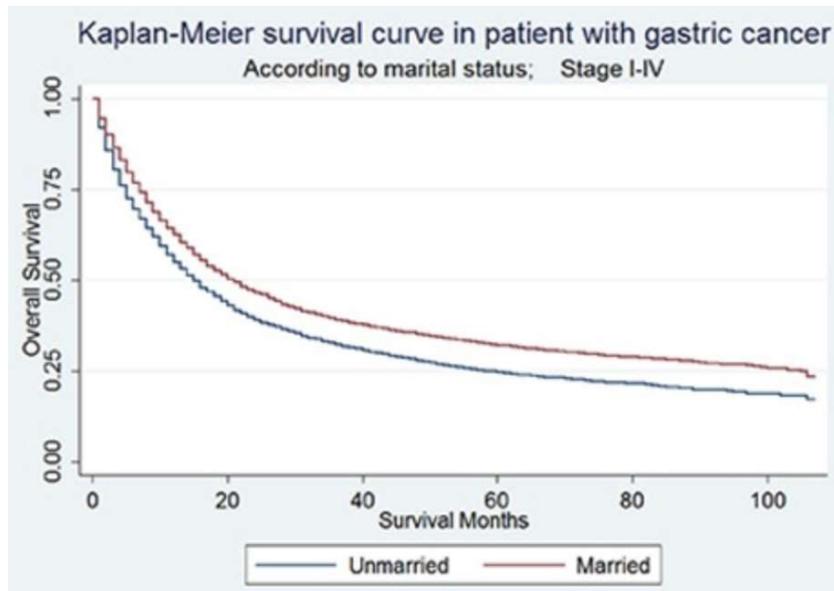
Source: Institute for the Future



Source: Intel Digital Health group

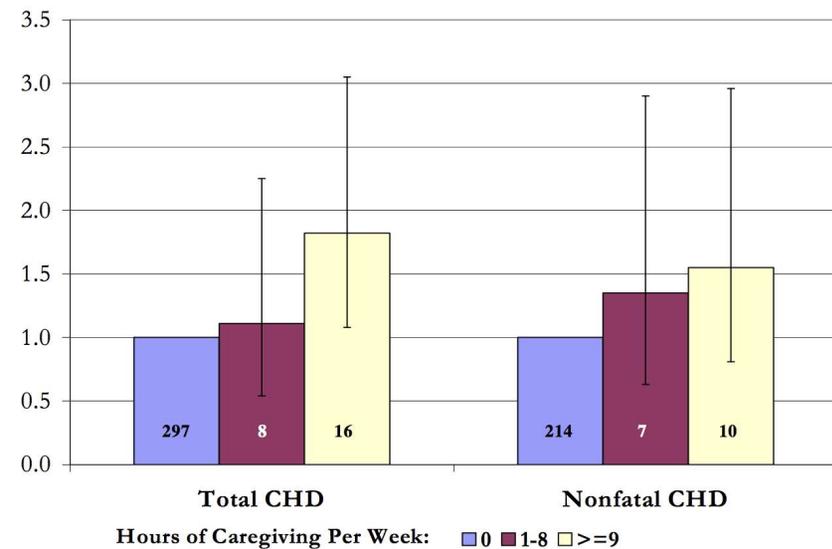
Social support networks

Benefit patients...



Zhang, et al. [Oncotarget](https://doi.org/10.18632/oncotarget.7399). 2017 Apr 4; 8(14): 22385–22405.
doi:[10.18632/oncotarget.7399](https://doi.org/10.18632/oncotarget.7399)

...but may also hurt caregivers



L Berkman, Director, Harvard Center for Population & Development Studies.
www.who.int/healthinfo/15_Social_Networks_Berkman_ok.pdf

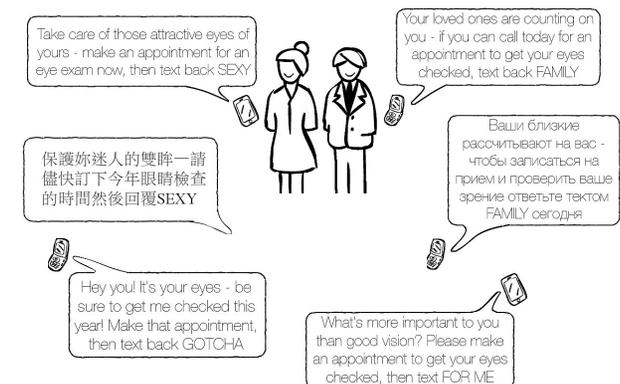
Individuals ⇌ communities

- Individual optimization ≠ societal optimization
- Conversely, social determinants of health are often essential for individual patients (e.g., Partners in Health, Roshan, peer support)
- Text messaging for chronic disease management → cost savings for diabetic patients... but ↑ utilization & reimbursements for cardiac patients

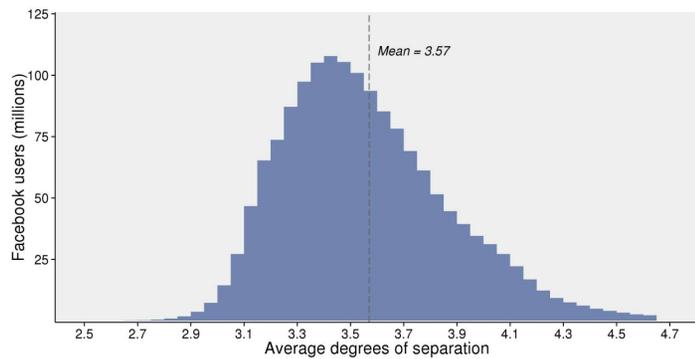
Causes of health variances

30-40%	Health behaviors
15-40%	Social & economic factors
20-30%	Genetics
10-25%	Health care
5-10%	Physical environment

www.healthaffairs.org/doi/10.1377/hpb20140821.404487/full/healthpolicybrief_123.pdf



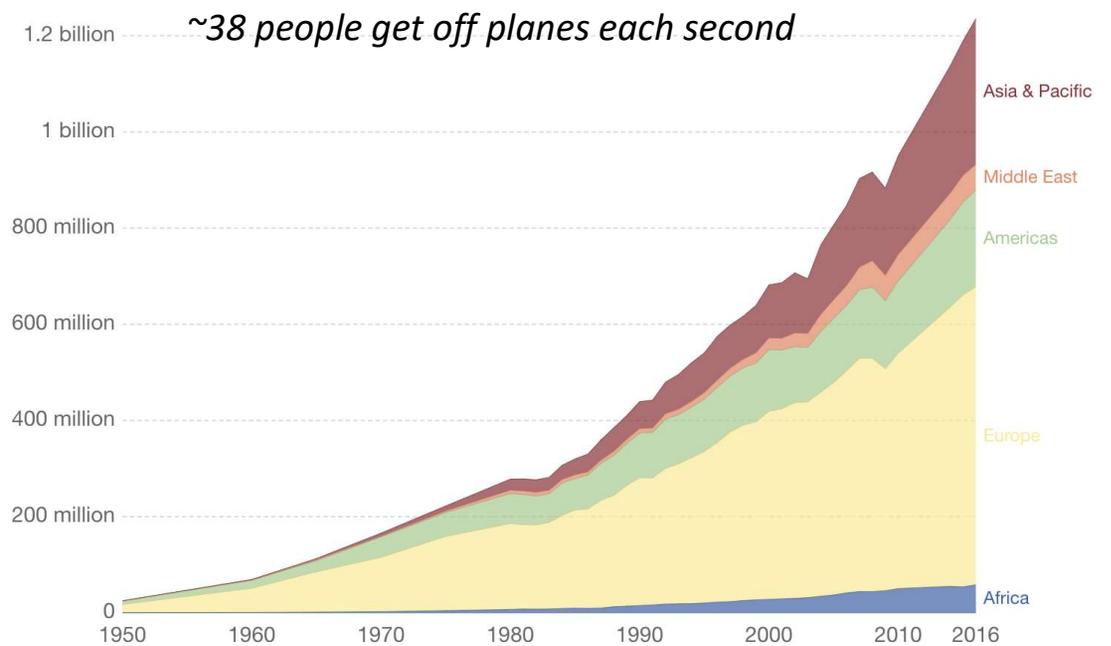
Individuals → communities



Facebook: 3.57 degrees of separation



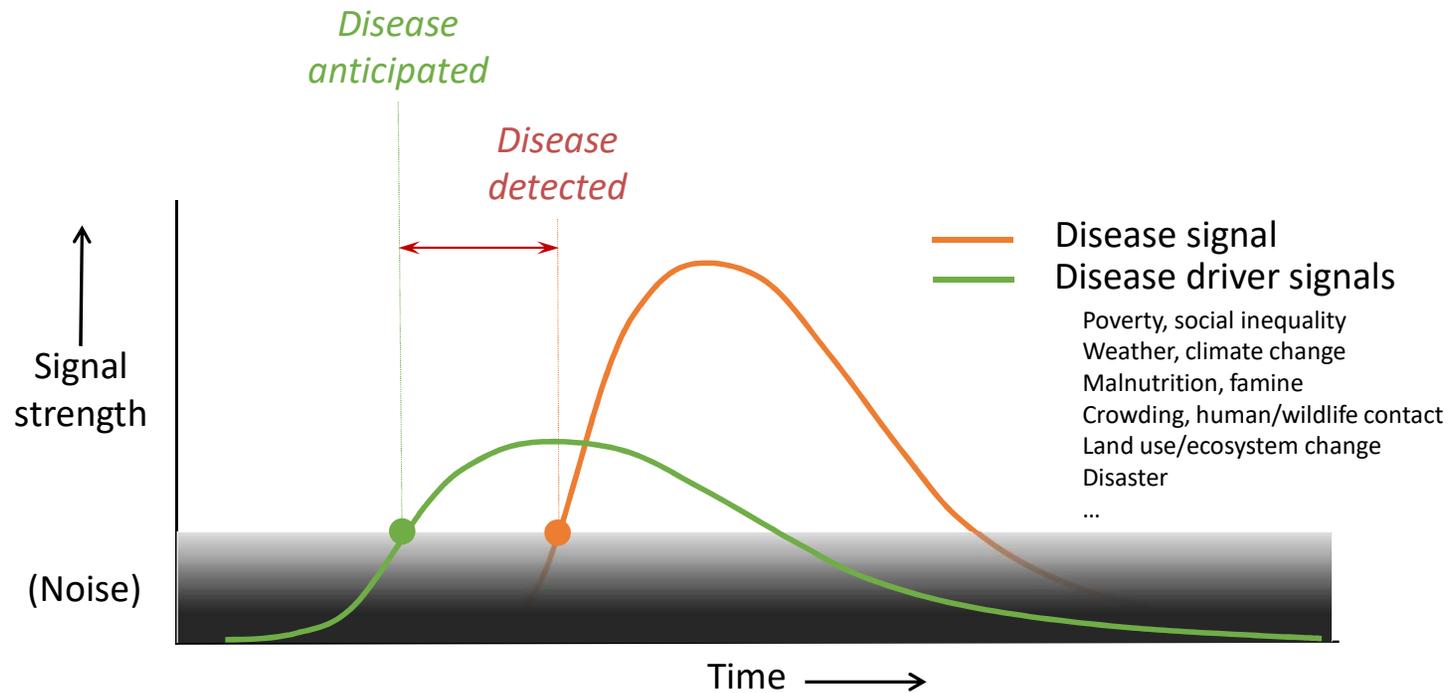
International tourist arrivals by world region



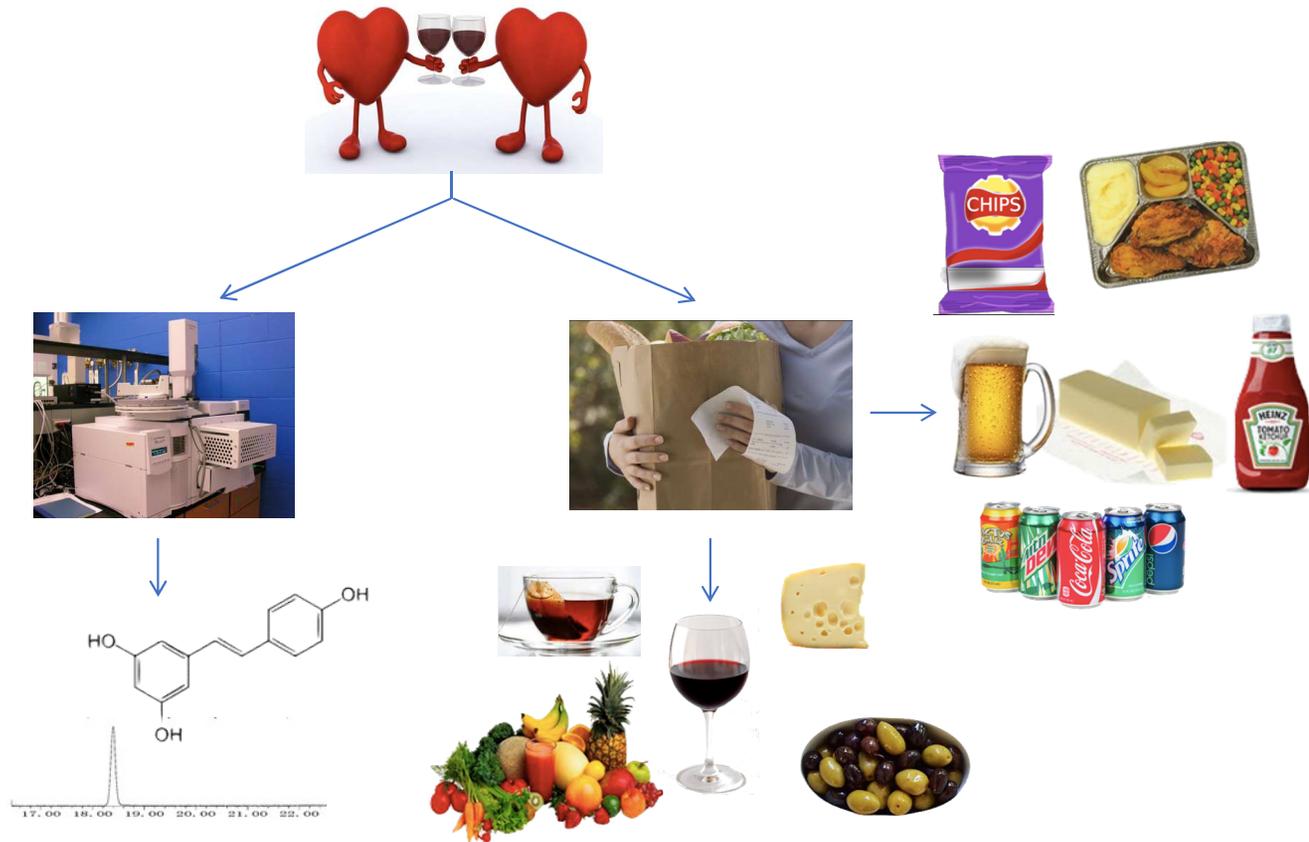
Source: United Nations World Tourism Organization (UNWTO) (2017)

<https://ourworldindata.org/tourism>

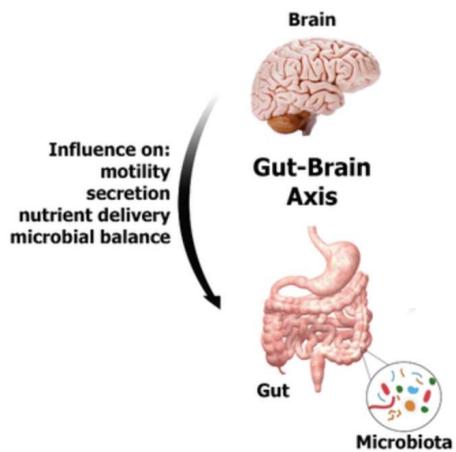
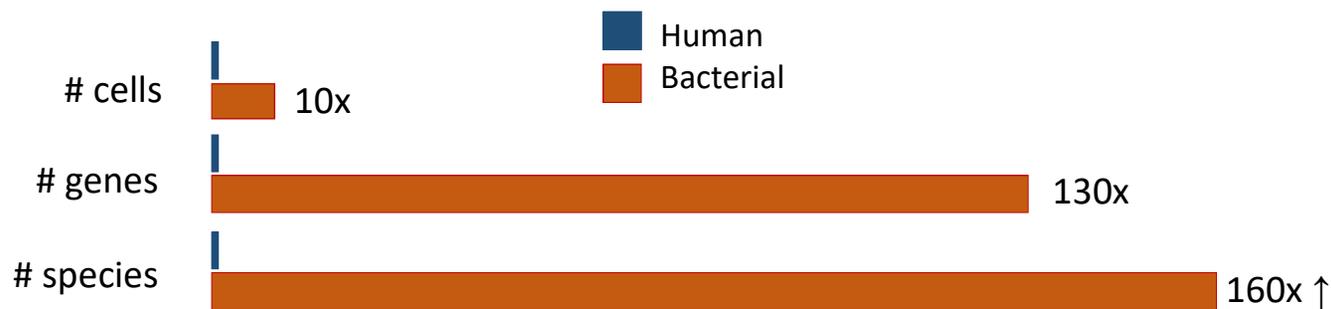
Data points (analytical) → data clouds (ecological)



Data points (analytical) → data clouds (ecological)



Microbiome



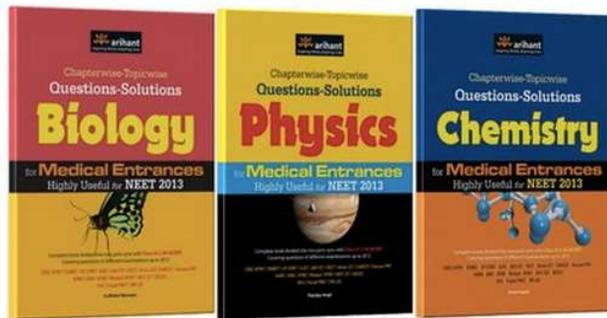
- Obesity
- Diabetes
- Heart disease
- Cancer
- Dementia
- Ageing
- Asthma
- Sleep
- Autism
- ...



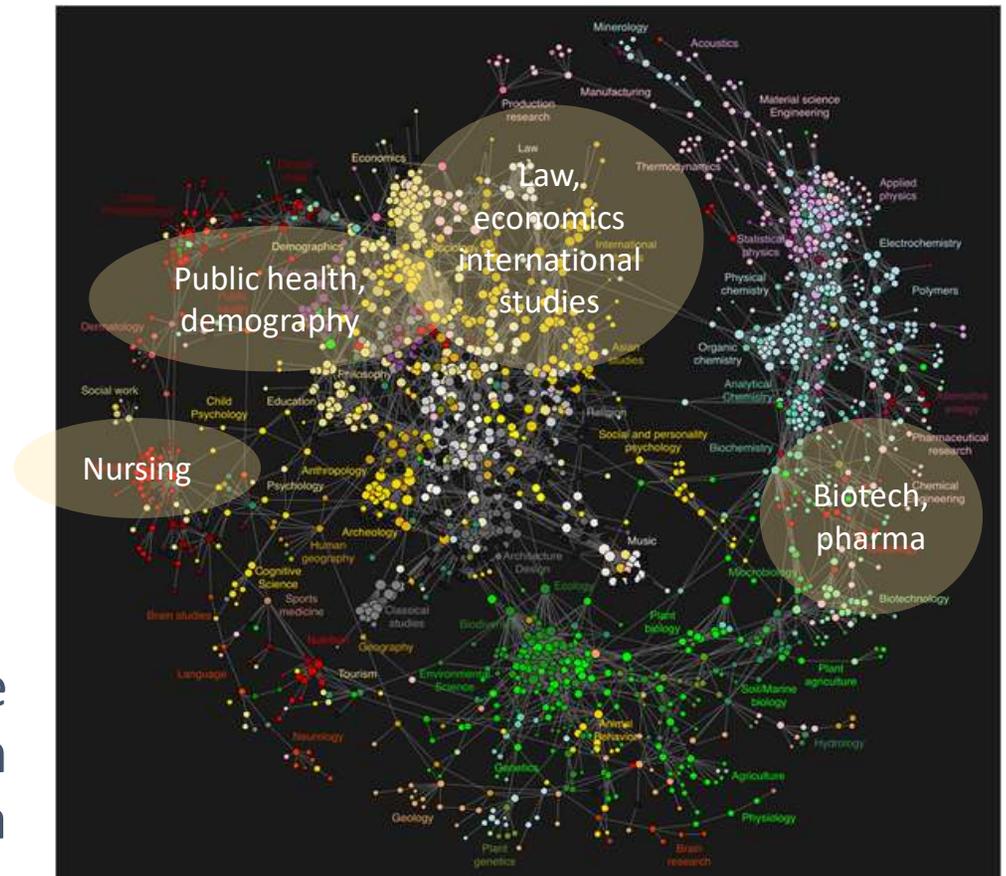
A broader lens (unit of analysis)

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Diseases → disease networks

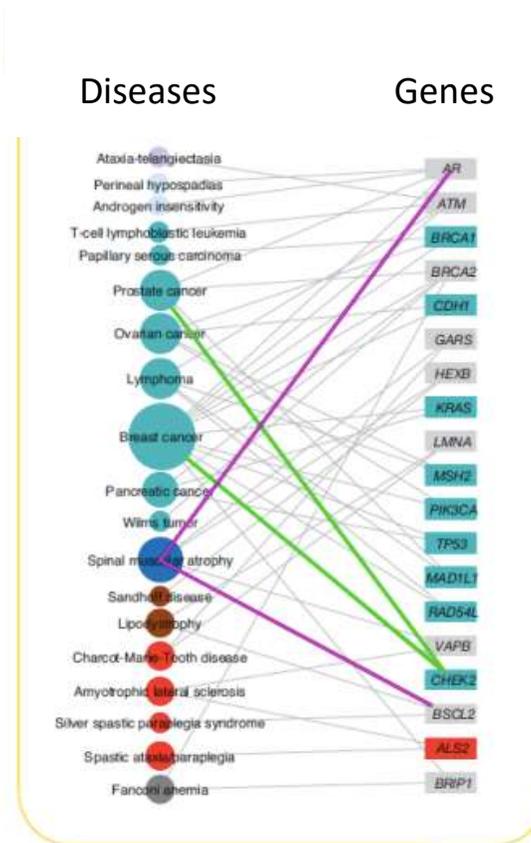
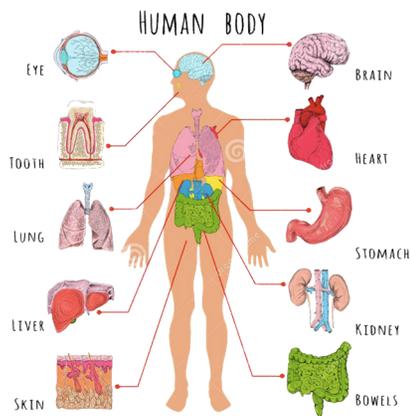


Map of science
derived from
clickstream data



Bollen J, Van de Sompel H, Hagberg A, Bettencourt L, Chute R, et al. (2009) Clickstream Data Yields High-Resolution Maps of Science. PLoS ONE 4(3): e4803. doi:10.1371/journal.pone.0004803
<http://127.0.0.1:8081/plosone/article?id=info:doi/10.1371/journal.pone.0004803>

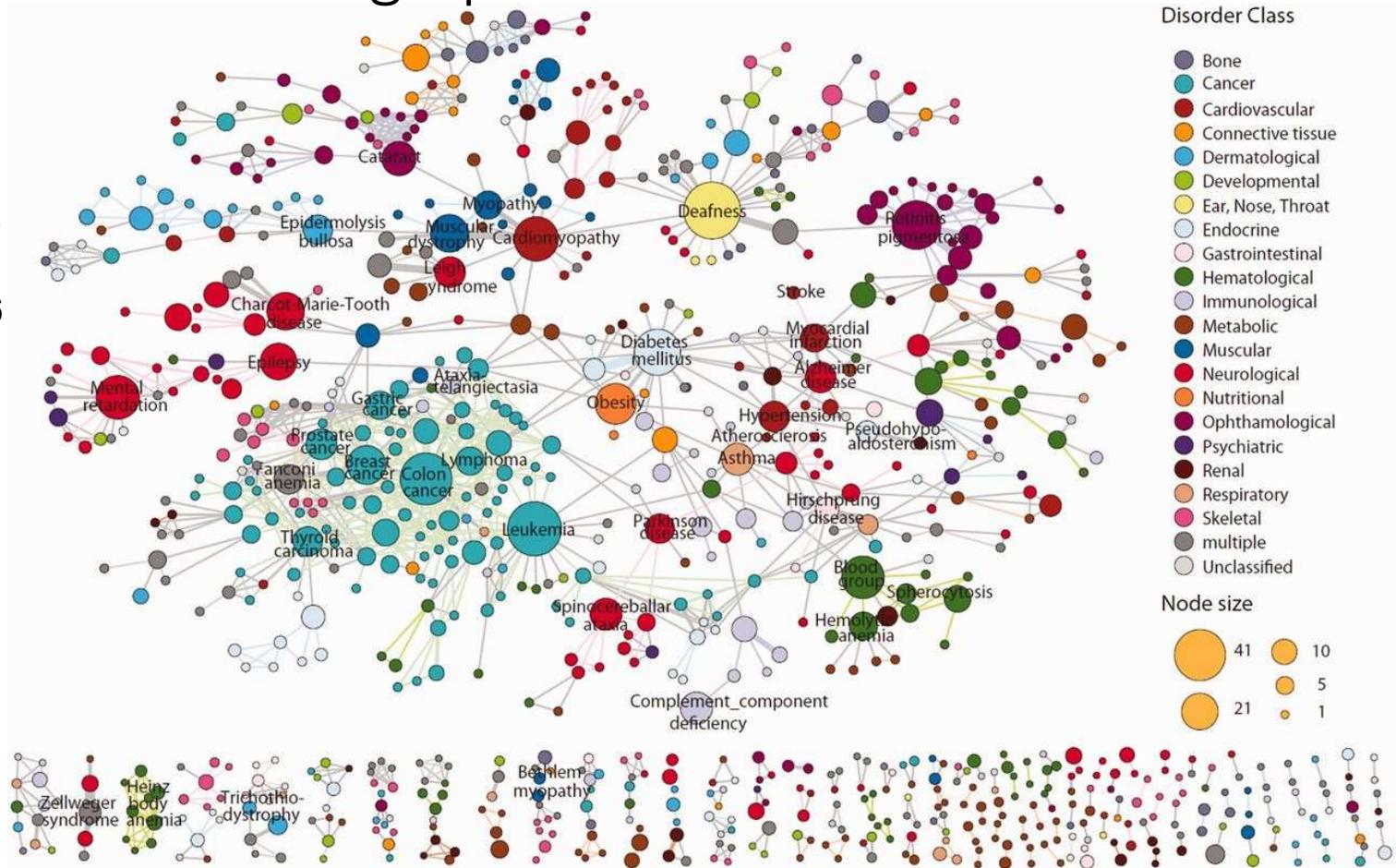
Geographic → genomic



Source: http://rocs.hu-berlin.de/complex_sys_2015/resources/Presentations/C_Mueller.pdf

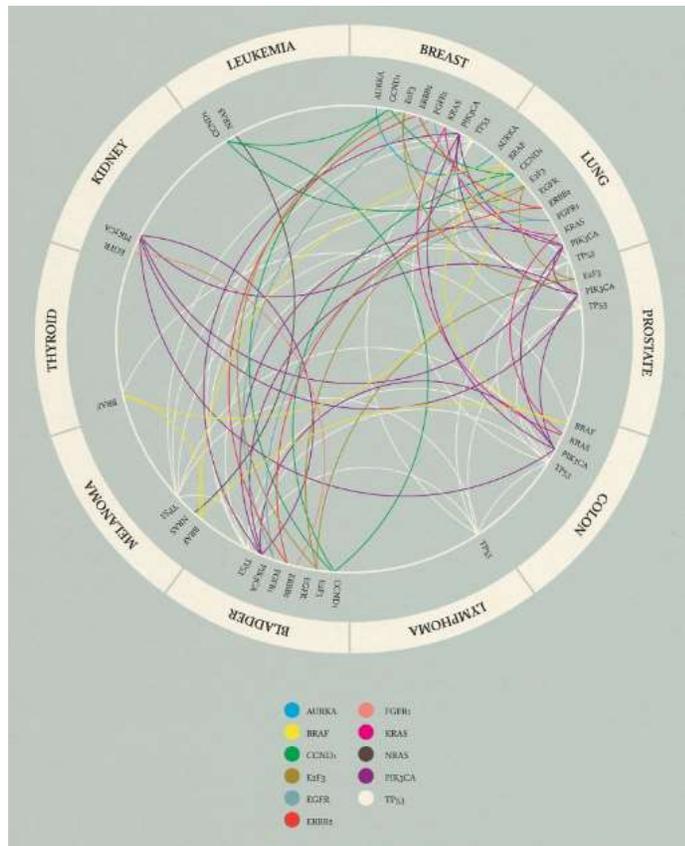
Human disease network graph

- 67% of disorders linked to at least one other
- Giant cluster contains 516 of 1284 (40%)

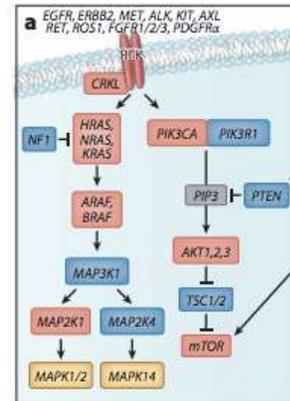


Kwang-Il Goh, and In-Geol Choi Briefings in Functional Genomics 2012;11:533-542

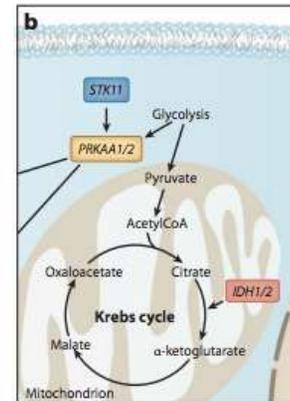
Re-classification of cancers



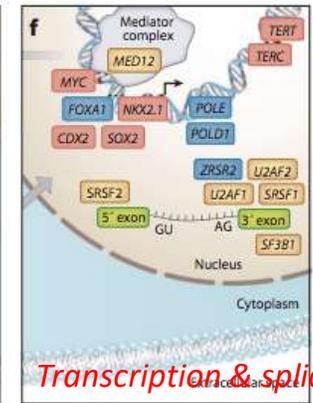
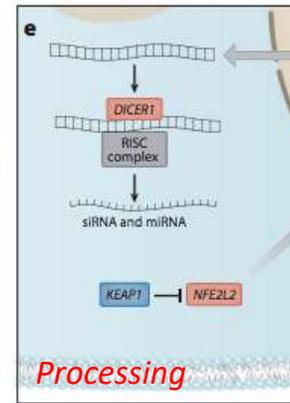
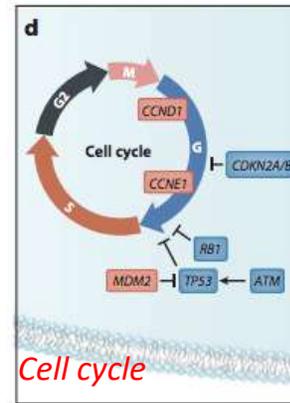
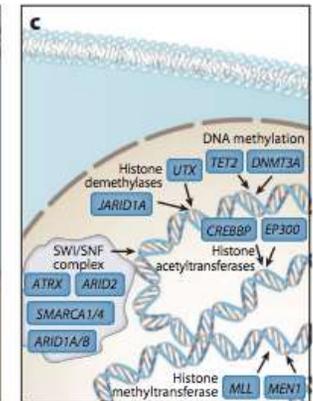
Signal transduction



Metabolism



Chromatin remodeling



Source: J Chmielecki & M Meyerson. 2013. DNA sequencing of cancer: what have we learned? Ann Rev Med 65:63-79.

■ Inactivating mutation/deletion
■ Activating mutation/amplification
■ Unknown effect
■ Other/non-mutant

DNA
 dsRNA
 ssRNA

More targeted cancer treatment



Source: J Chmielecki & M Meyerson. 2013. DNA sequencing of cancer: what have we learned? *Ann Rev Med* 65:63-79.

Classification of common human diseases derived from shared genetic and environmental determinants

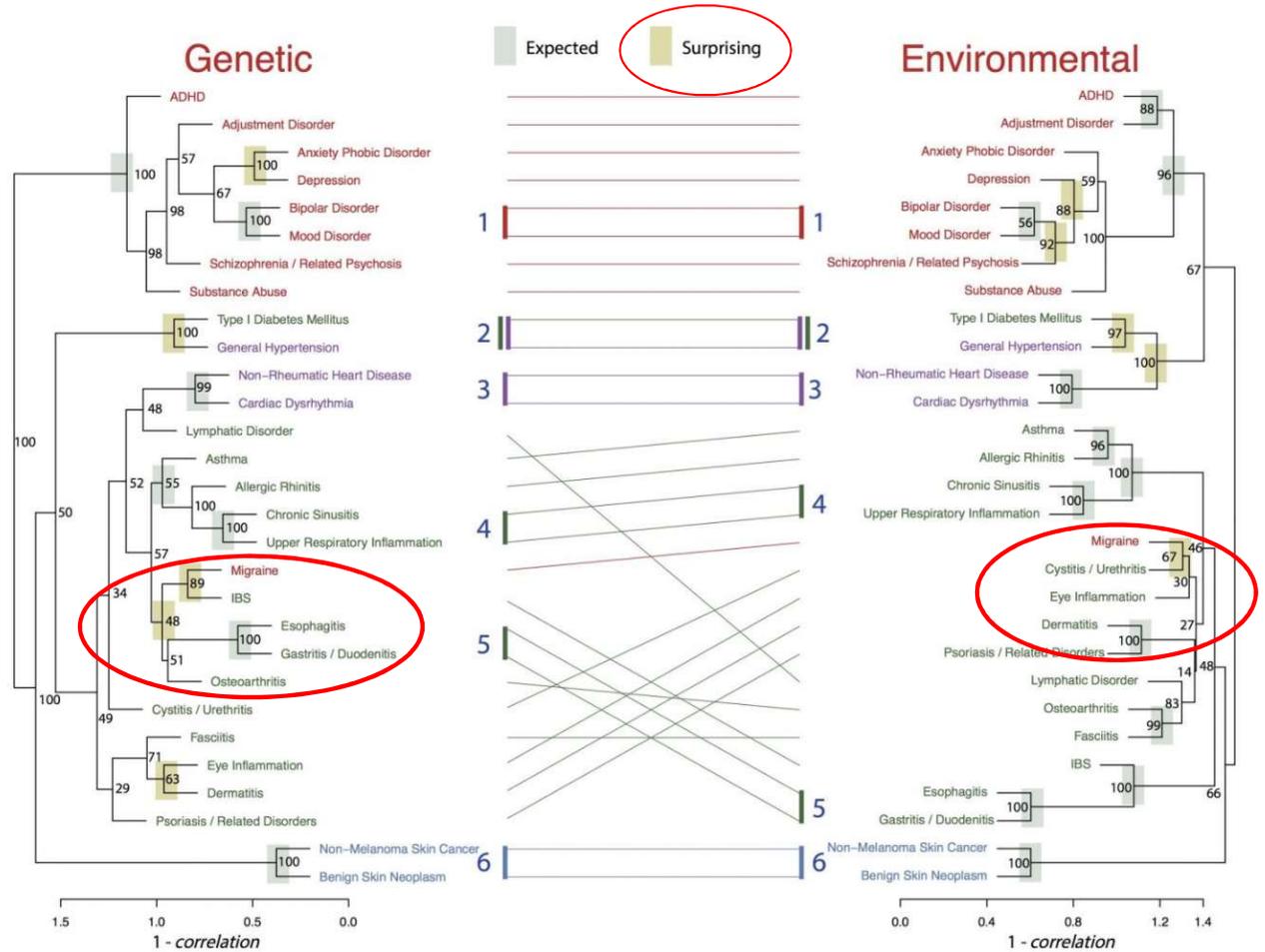
Kanix Wang, Hallie Gaitsch, Hoifung Poon, Nancy J Cox & Andrey Rzhetsky

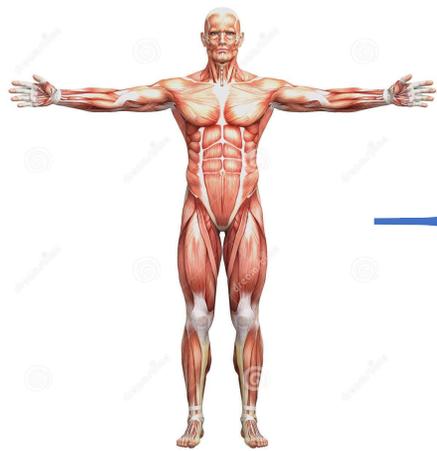
Affiliations | Contributions | Corresponding author

Nature Genetics 49, 1319–1325 (2017) | doi:10.1038/ng.3931

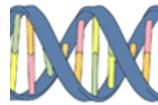
Received 16 September 2016 | Accepted 12 July 2017 | Published online 07 August 2017

Migraine closely related genetically to irritable bowel & environmentally to inflammation of the urinary tract → common mechanisms?



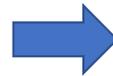
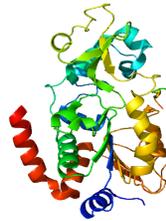


genes



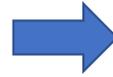
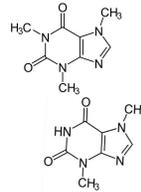
genomics

proteins



proteomics

metabolites

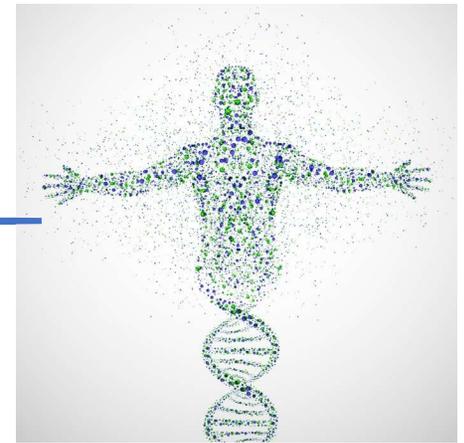


metabolomics

bacteria

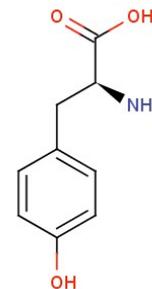
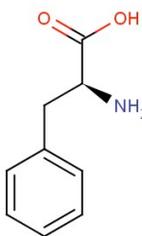
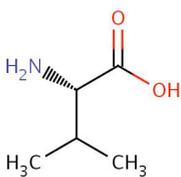
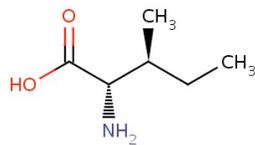
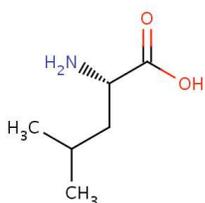
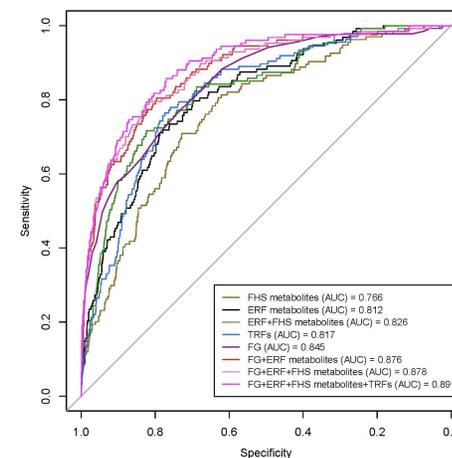


microbiomics



Predicting diabetes

- 12 years prior; 4-fold risk
- Metabolomic profiling superior to fasting blood glucose (AUC 0.89 vs. 0.84)



A broader lens (unit of analysis)

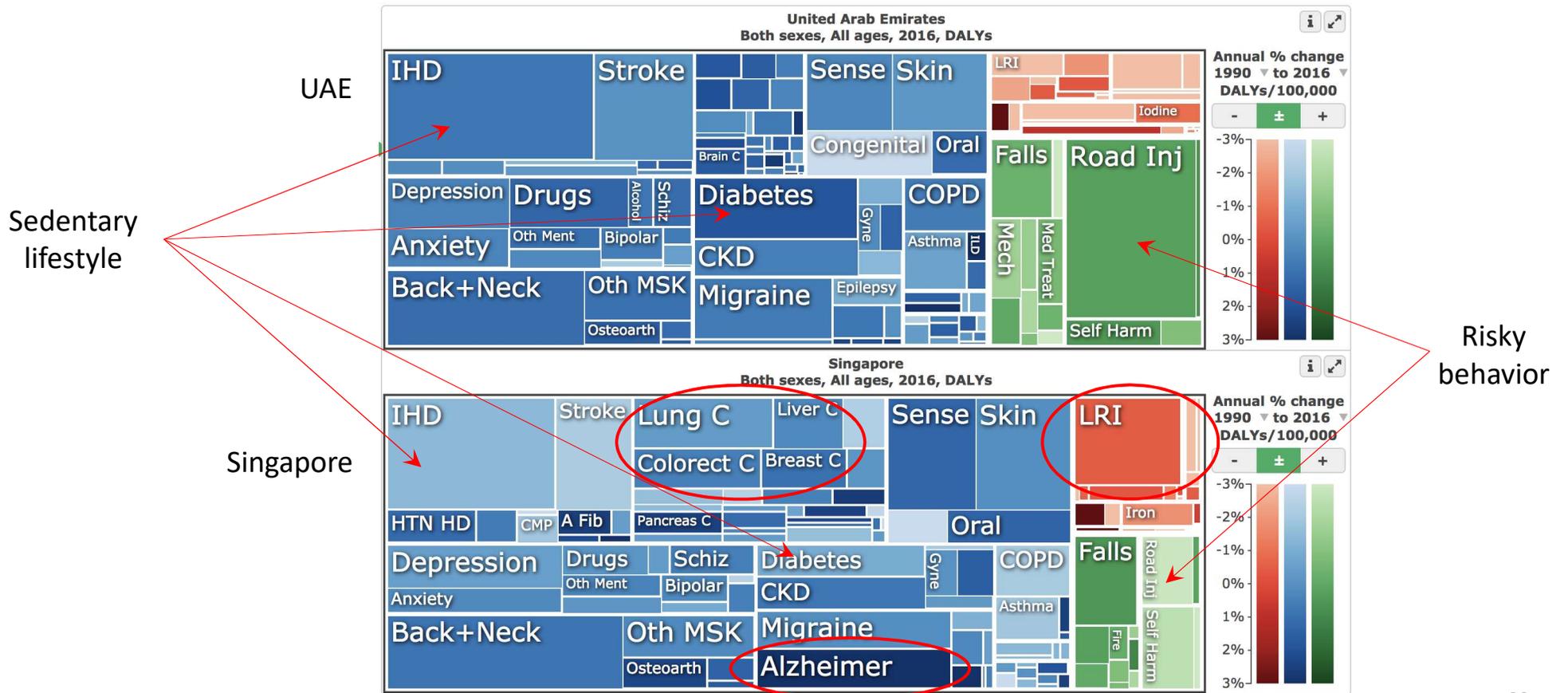
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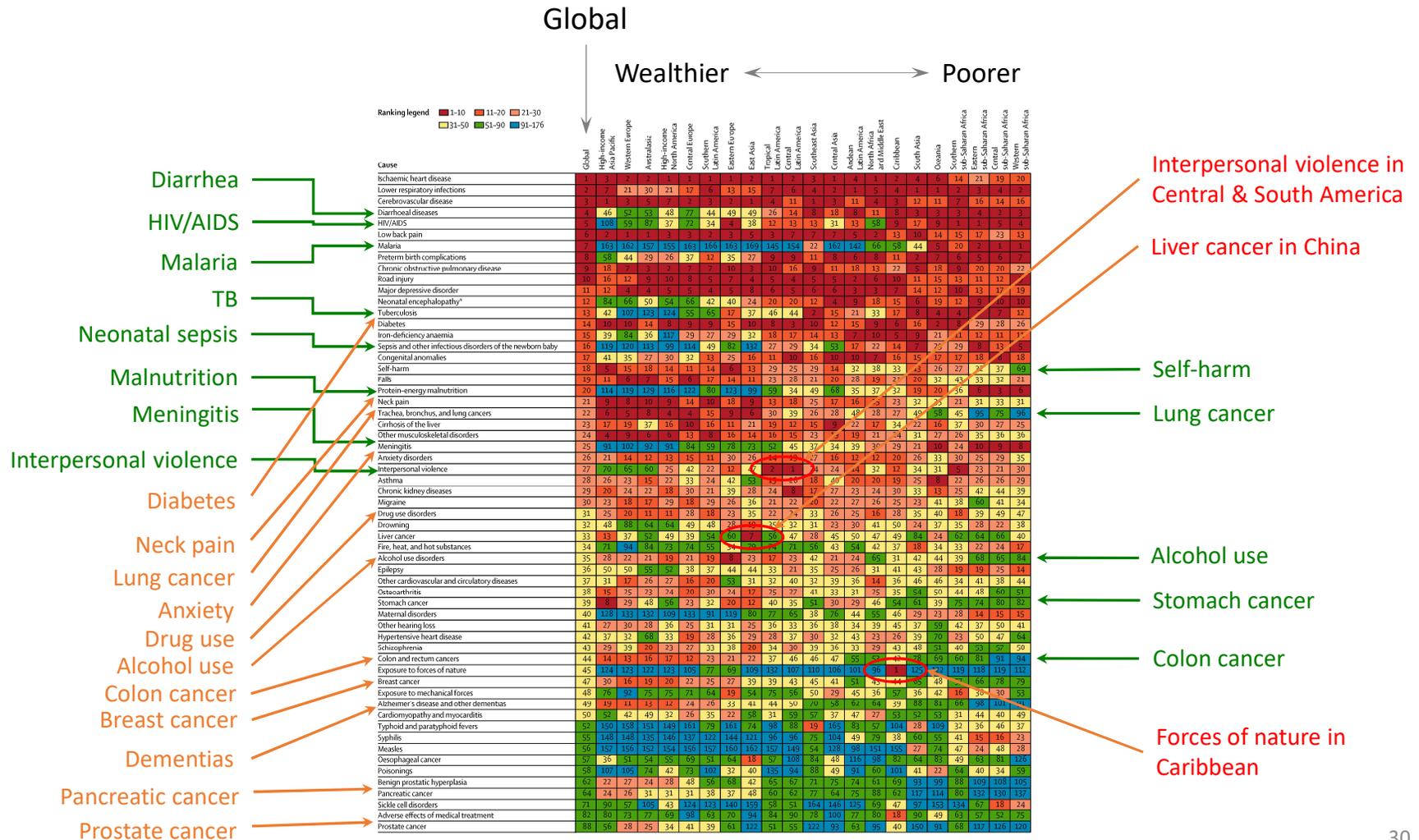
Technical → sociotechnical

Context matters...



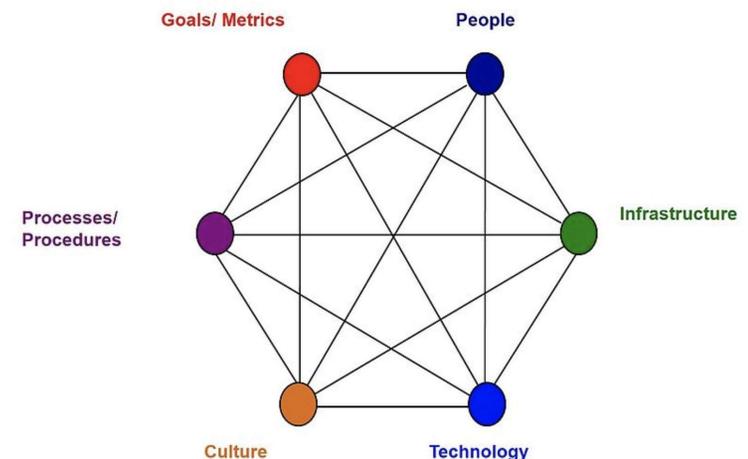
Risks don't exist in a vacuum...



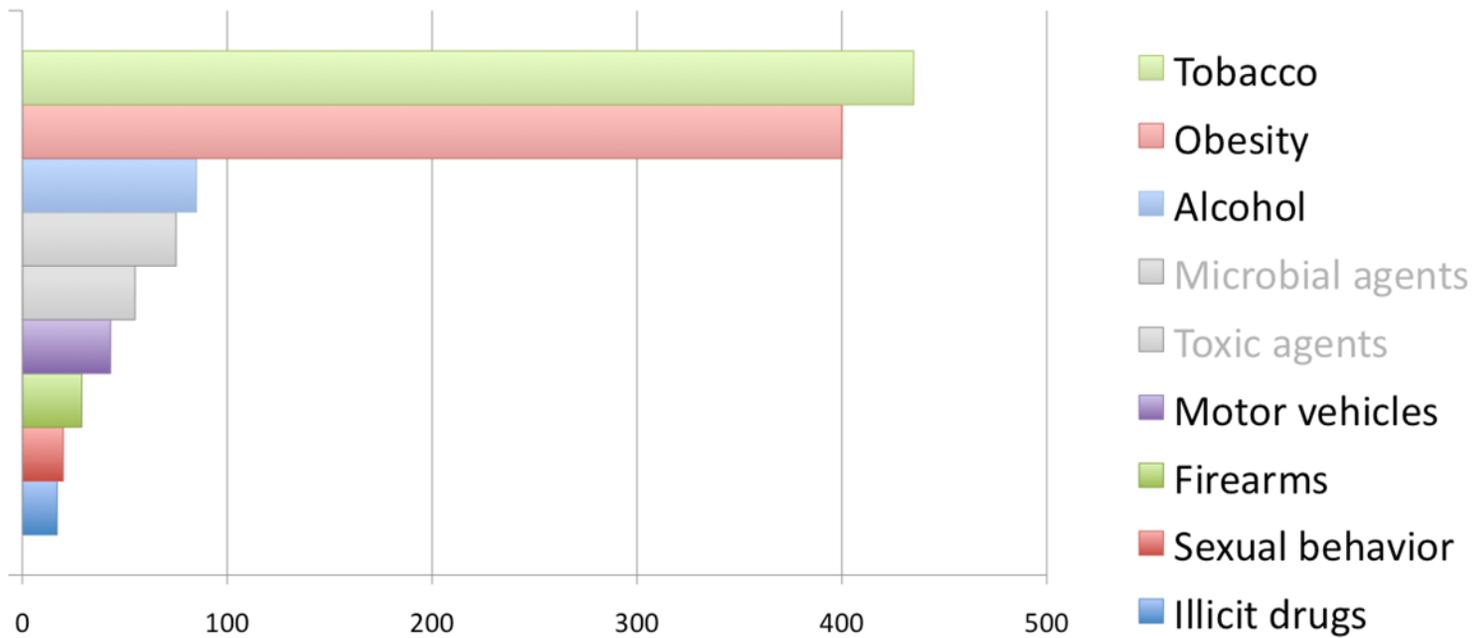


...& neither does technology

- Users & their culture/beliefs
 - Built into product design
 - Determine acceptance/resistance, praxis, unintended consequences (60-80% EHR failure rate)
 - Actor network / sociotechnical theory enables joint optimization (human + technical)
- Business models
 - Tech innovations have greater impact when embedded in disruptive business models - Clayton Christensen
 - “We have gone from genomics to 'universal'- omics, but the **real challenge** is how we translate this newfound knowledge into products that will improve and meet the needs of patients.” - Bill Dalton, PhD, MD, PMWC Program Co-Chair



Behavioral determinants of health



Source: : Mokdad, et al. 2004. Actual causes of death in the United States, 2000. JAMA. 2004;291:1238-45.

Technobiome

“A house is a machine for living in.”

- Le Corbusier. Vers Une Architecture. 1923.



“... joining and separation of human and nonhuman are everyday affairs.”

- Suchman. Human-Machine Reconfigurations. 2007.



Ethical dilemmas



- Moratorium on gene editing?
- Transhumanism, biohacking, nootropics

 reddit
COMMUNITY DETAILS
 r/Nootropics
152k Subscribers | 716 Online
Discussion of nootropics and cognitive enhancers.

“Monitoring the future”: prevalence (%) of drugs, 2017

	8 th graders	10 th graders	12 th graders
Amphetamines	5.7	8.2	9.2
Adderall	1.3	4.0	5.5

Global Challenges

12 Risks that threaten human civilisation



Extreme Climate Change



Nuclear War



Global Pandemic



Ecological Catastrophe



Global System Collapse



Major Asteroid Impact



Super-volcano



Synthetic Biology



Nanotechnology



Artificial Intelligence



Unknown Consequences



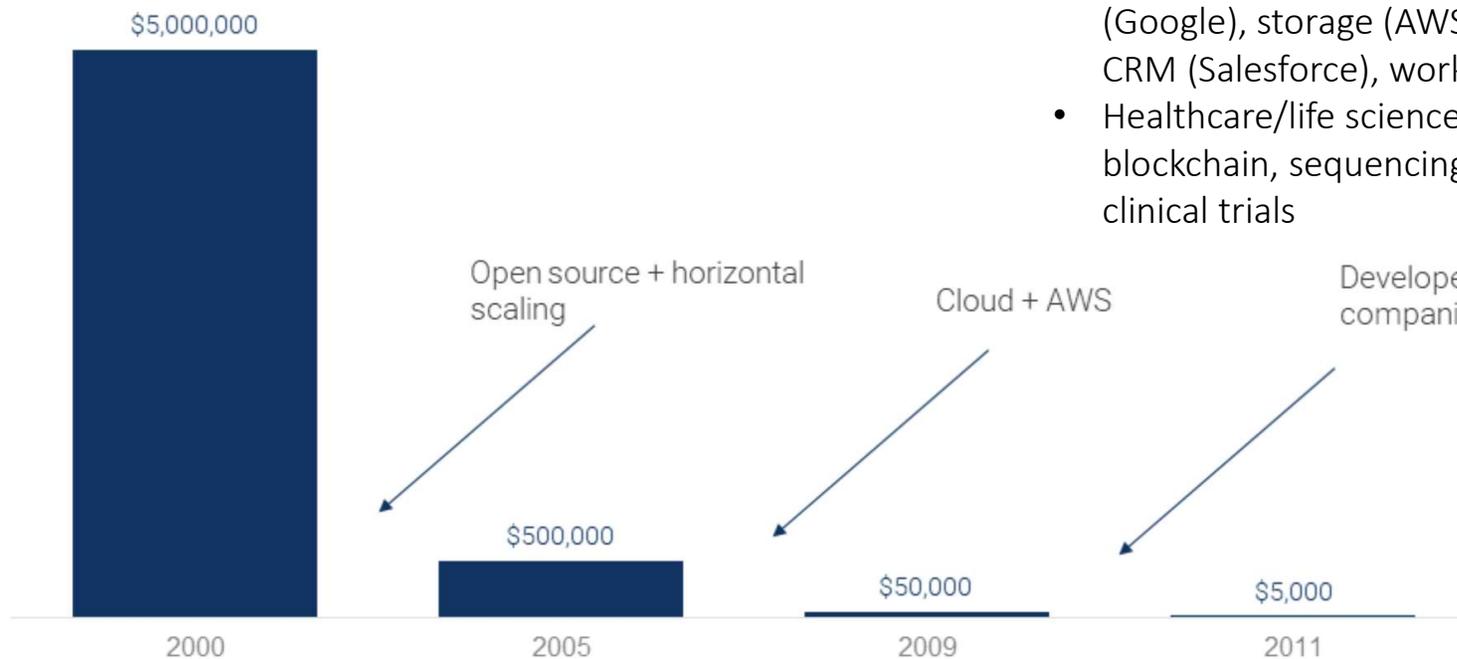
Future Bad Global Governance



<https://api.globalchallenges.org/static/wp-content/uploads/12-Risks-with-infinite-impact.pdf>

Platforms

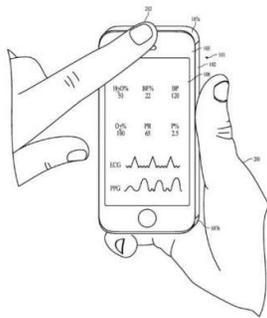
Costs to launch an internet tech startup (approximately)



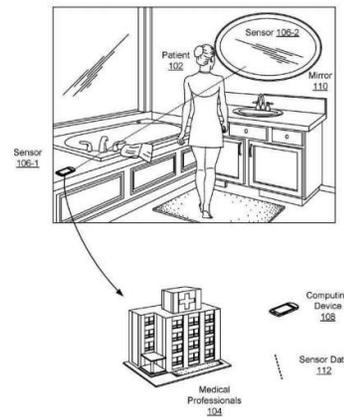
Approach: strip out part of the value chain & turn it into a utility

- Startups: code repositories (GitHub), analytics (Google), storage (AWS), teamwork (Slack), CRM (Salesforce), workspace (WeWork)
- Healthcare/life sciences: AI/discovery, blockchain, sequencing, lab services, reagents, clinical trials

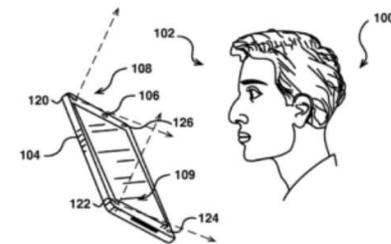
New entrants / wild cards



Patent: Turning your phone into a monitoring device



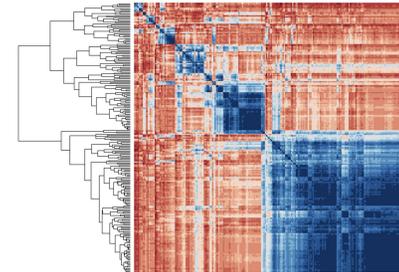
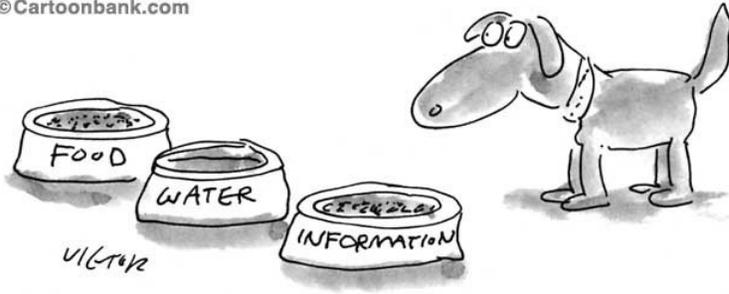
Patent: Optical sensors in your bathroom to monitor blood flow



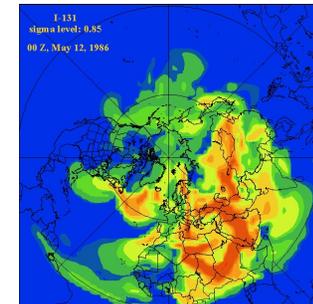
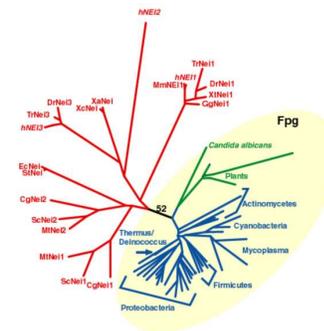
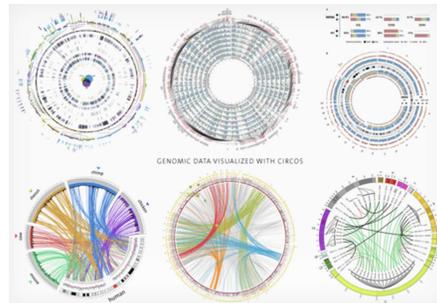
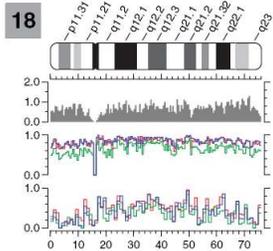
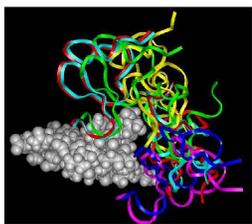
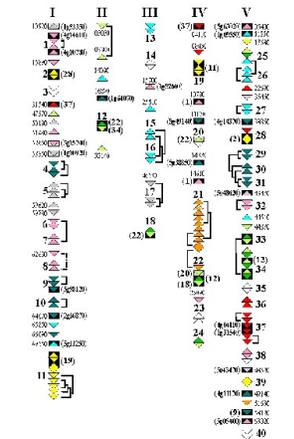
Patent: Wireless heart rate detection

Source: Nikhil Krishnan, CB Insights

©Cartoonbank.com



- New data types
 - Beyond usual text, tracings, & images
- New data sources
 - Outside of the hospital, clinic & lab
- ...create new information management challenges



New data, new connections

- Health x economics
 - For 22,000 workers in 11 European countries, each year of economic stress (GDP ↓ >1%) ≈ ageing 2 years
- Health x social media
- Data surveillance industry ~\$156B/yr (2x combined US intelligence agencies)
 - Acxiom has ~1500 fields for >700M people worldwide, including 96% of US households; 70 clusters for predictive & behavioral targeting



Long-term health consequences of recessions during working years

Liudmila Antonova^{a, 1}, Tabea Bucher-Koenen^{b, 1}, Fabrizio Mazzonna^{a, 2}



More Conscientious

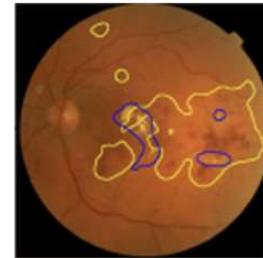


Less Conscientious



The Use of Craigslist Posts for Risk Behavior and STI Surveillance
 Jason A. Fries, Alberto Segre, Ph.D., Linnea Polgreen, Ph.D., Philip Polgreen, M.D.
 Computational Epidemiology Research Group, University of Iowa

106 STARTUPS TRANSFORMING HEALTHCARE WITH AI

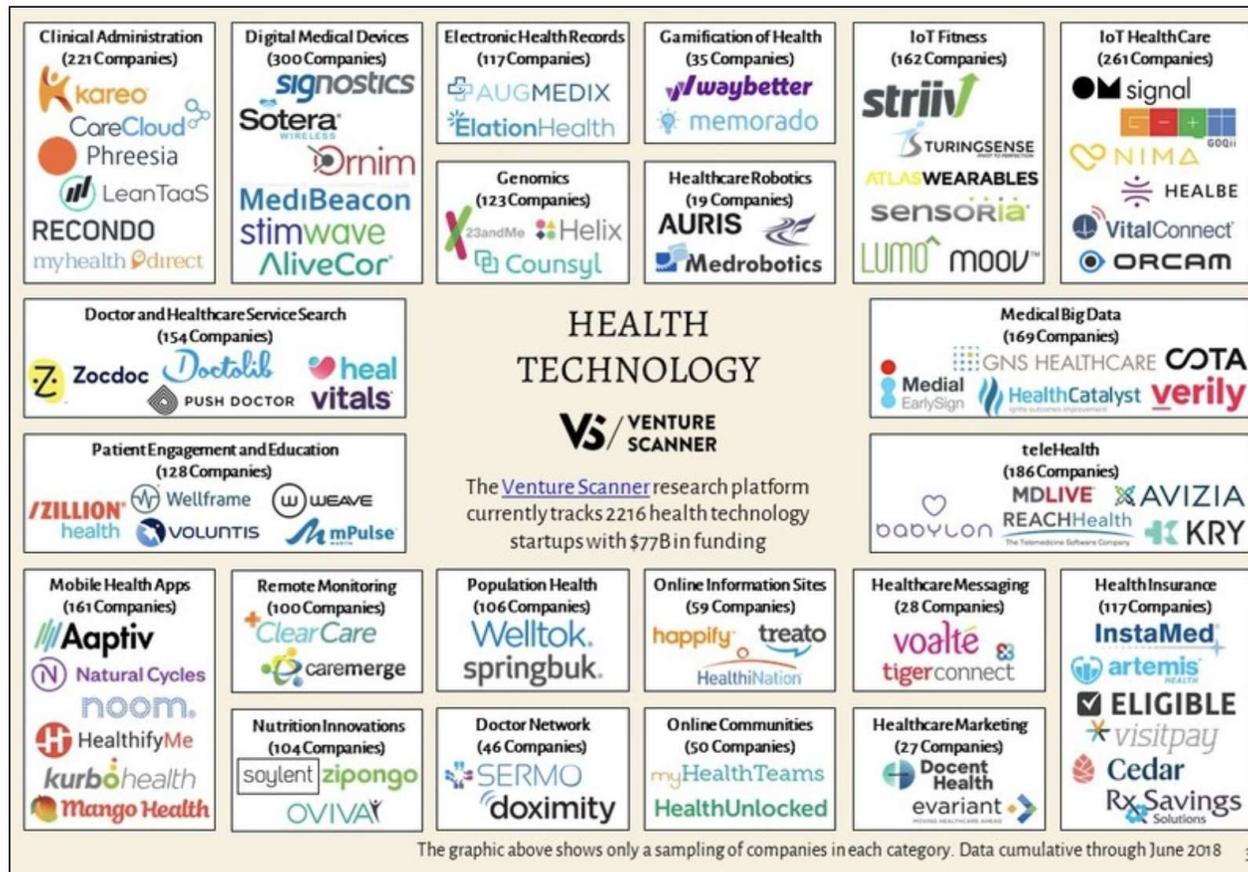


CBINSIGHTS

Some local snapshots

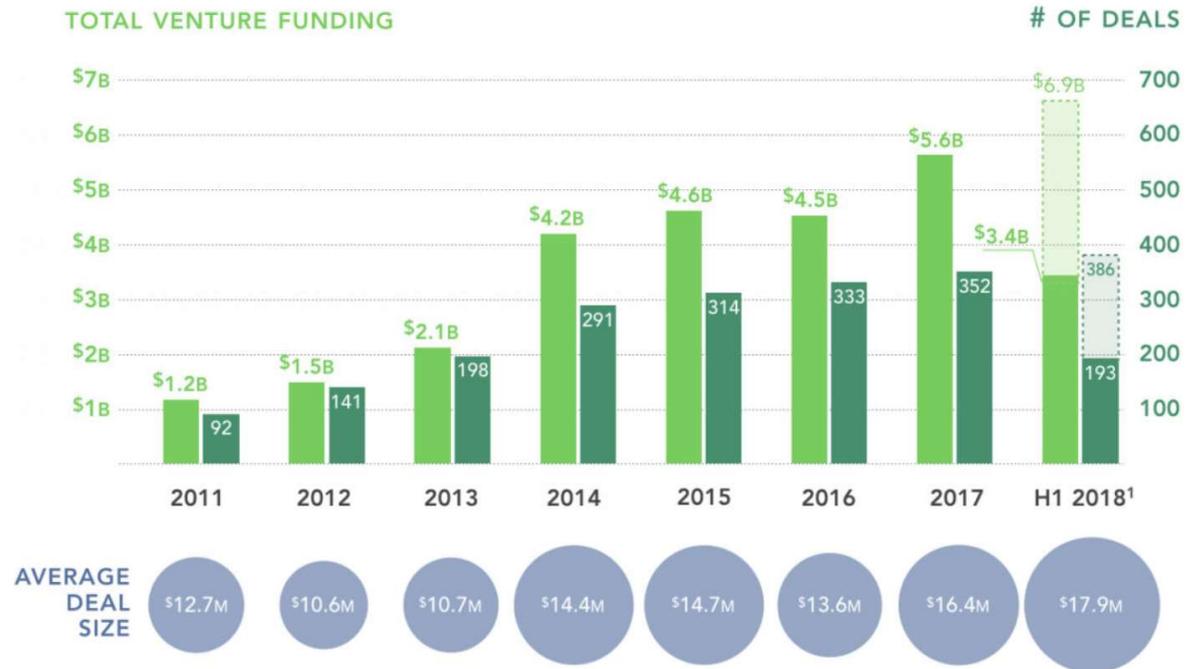
- Silicon Valley
- Middle East

2216 health/tech startups, \$77B funding



Digital health 2018: ~400 deals, \$6.9B

DIGITAL HEALTH FUNDING
2011-H1 2018

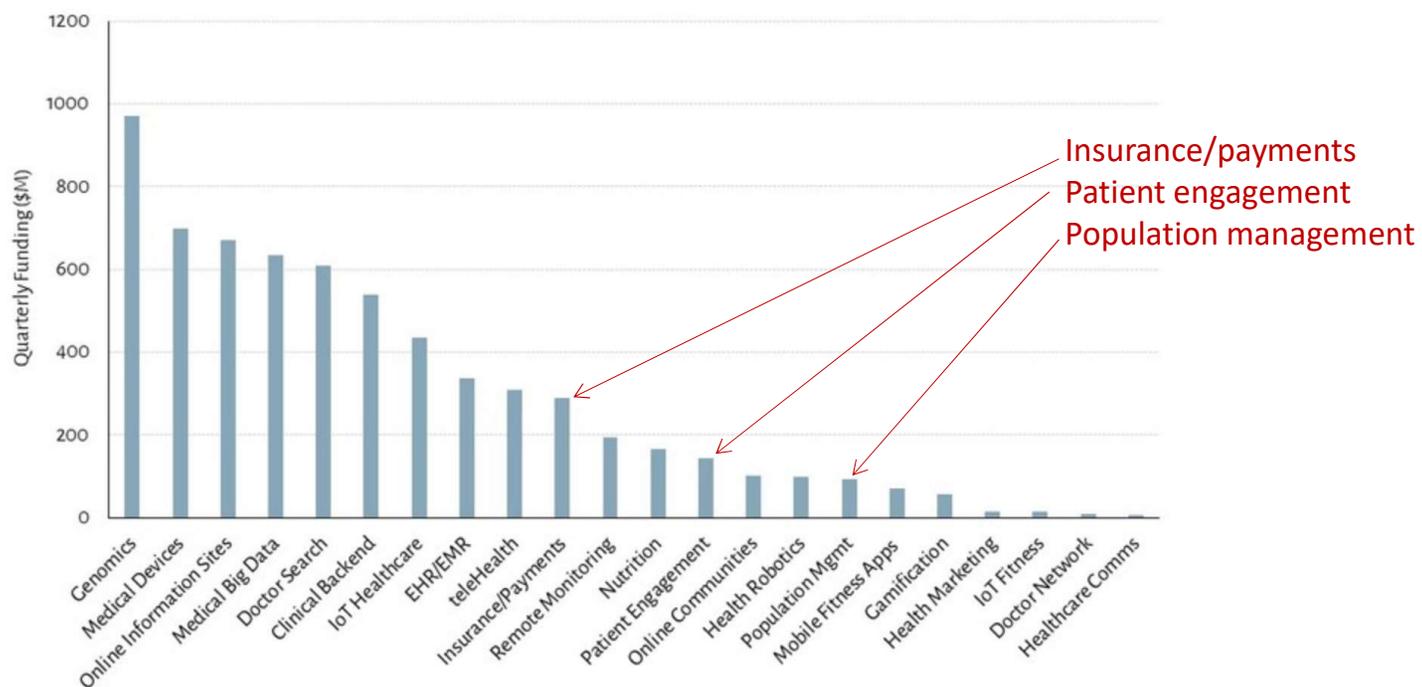


Source: Rock Health Funding Database
 1: Shaded portion shows projections for entire year of 2018, assuming current funding pace continues.
 Note: Only includes U.S. deals >\$2M; data through June 30, 2018

Health/tech startup funding, 2Q2018

HEALTH TECHNOLOGY
Latest Quarter Category Funding

VS/ VENTURE
SCANNER



Data cumulative through June 2018

InsurTech – 876 companies

<p>Automotive (113 Companies)</p>	<p>Employee Benefits (31 Companies)</p>	<p>Enterprise/Commercial (100 Companies)</p>	<p>Health/Travel (93 Companies)</p>	<p>Data/Intelligence (78 Companies)</p>
<p>Consumer Management (40 Companies)</p>	<p>InsurTech Venture Scanner</p> <p>Contact info@venturescanner.com to access the full landscape report with all 876 companies</p>		<p>Comparison/Marketplace (233 Companies)</p>	
<p>Education/Resources (29 Companies)</p>			<p>Infrastructure/Backend (168 Companies)</p>	
<p>User Acquisition (48 Companies)</p>	<p>Life, Home, P&C (92 Companies)</p>	<p>P2P Insurance (28 Companies)</p>	<p>Product (22 Companies)</p>	<p>Reinsurance (30 Companies)</p>

Some recent health/tech startups (& themes)

- Rapid DNA sequencing & microbiome
 - Pathogenomix promises 5 minute pathogen identification via curated sequence databases
- Mental & behavioral health
 - Zenful - engaging students via adaptive messaging
- Re-purposing drugs based on new understanding of underlying disease mechanisms
 - Exelogen – treating intracranial pressure by re-purposing GLP-1R drugs used for diabetes & obesity
- New forms of imaging enabled by AI
 - LifeWave – radiofrequency monitoring of lung congestion (CHF, ARDS, COPD) – interestingly, doing clinical trials in US & China
 - Tibot – AI enhanced skin lesion diagnosis





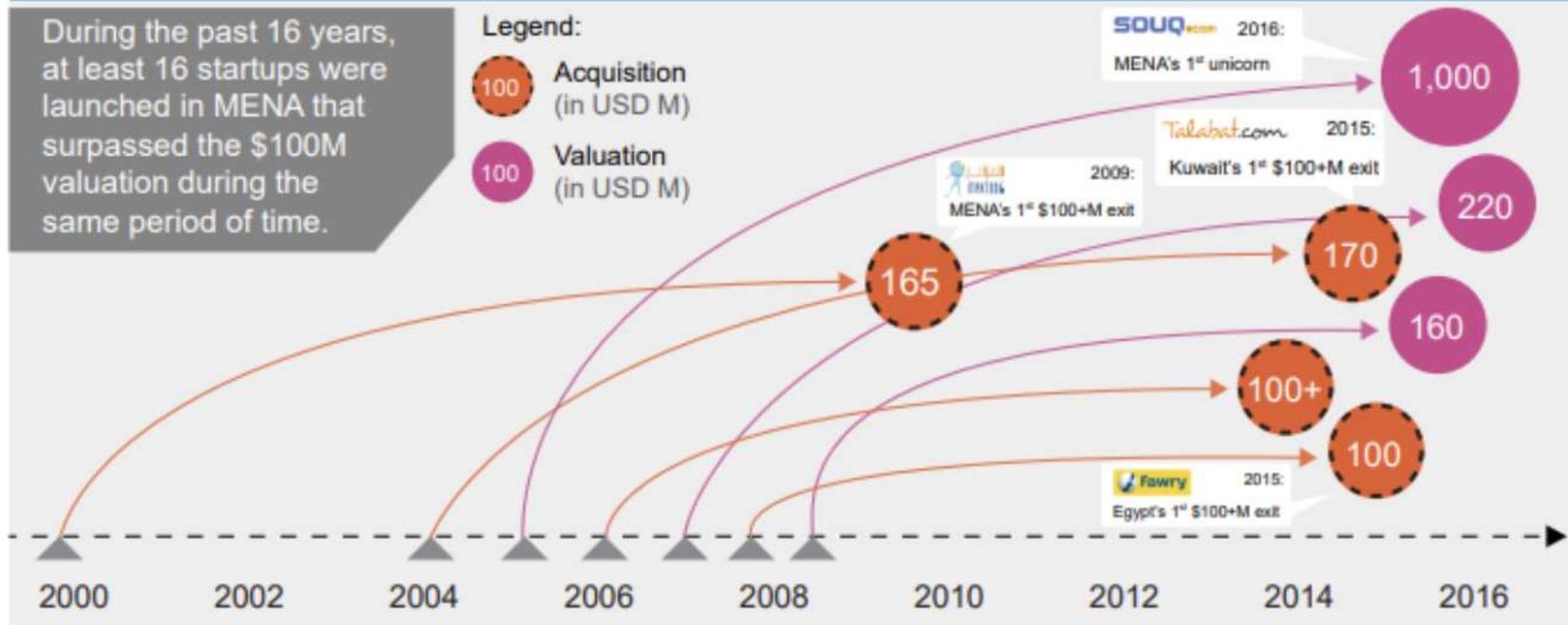
MENA - based startups crossing the \$100M valuation

During the past 16 years, at least 16 startups were launched in MENA that surpassed the \$100M valuation during the same period of time.

Legend:

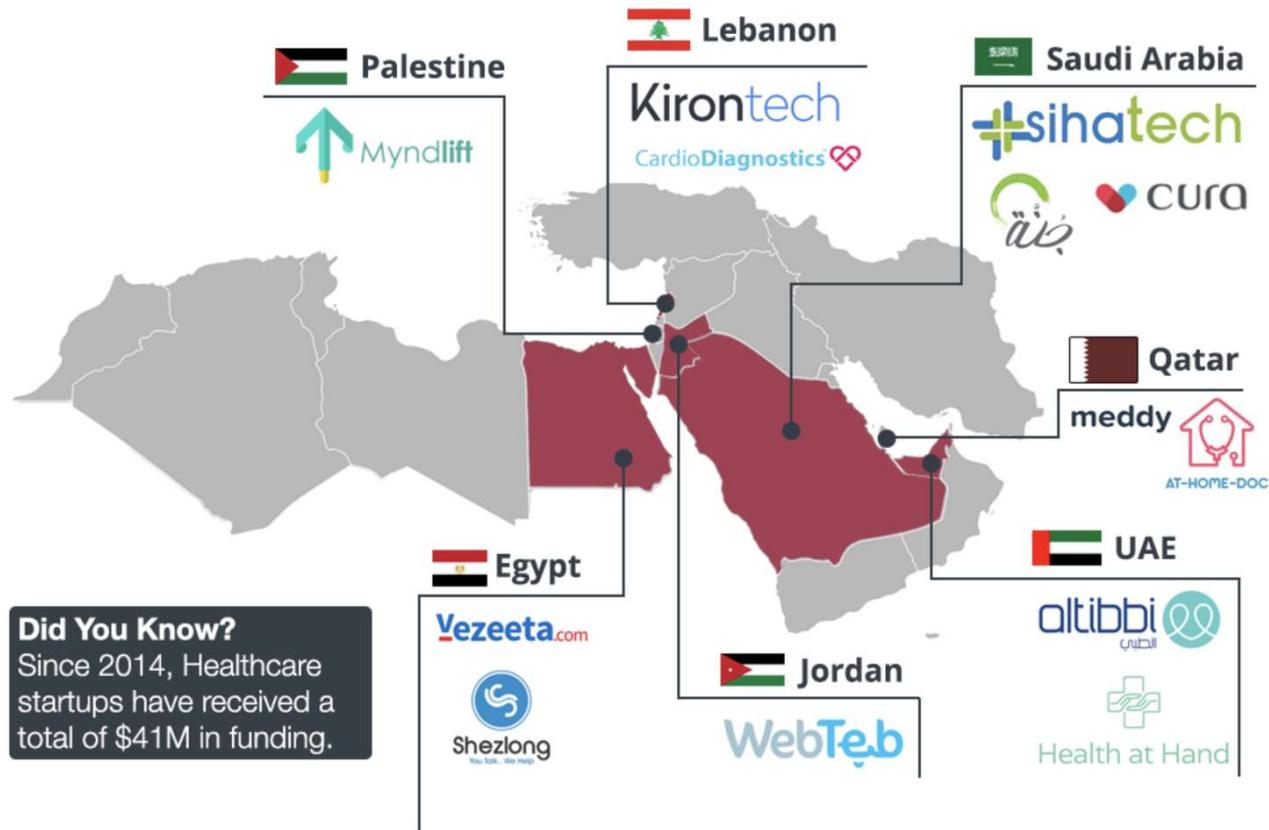
100 Acquisition (in USD M)

100 Valuation (in USD M)



Source: Wamda²⁵

⊕ Top Funded Digital Healthcare Startups in MENA ⊕



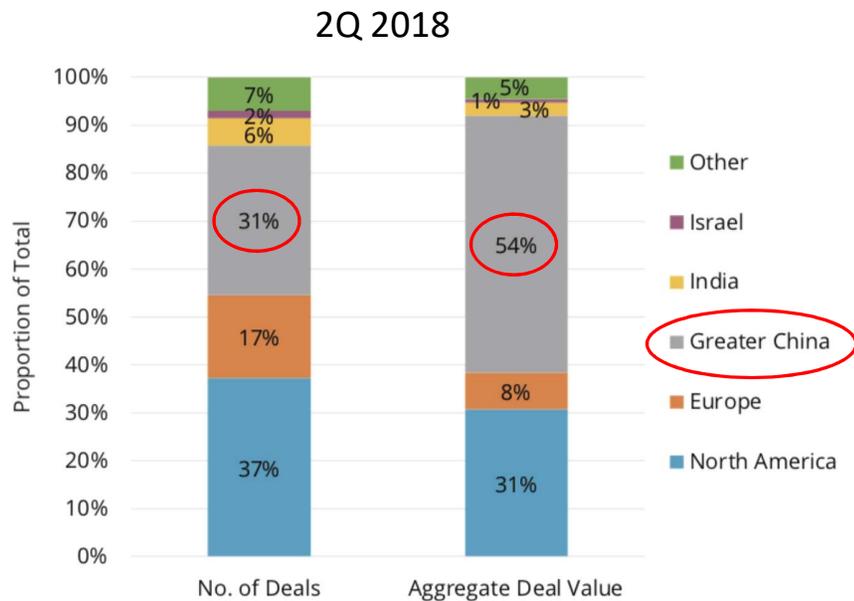
Did You Know?
Since 2014, Healthcare startups have received a total of \$41M in funding.

/Magnitt

MAGNITT_MENA

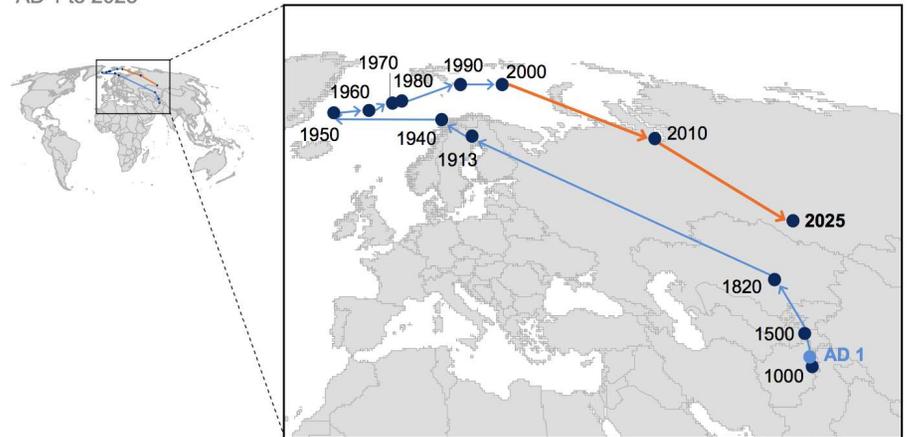
magnitt_mena

Asia surpassing US?



Source: Preqin

Evolution of the earth's economic center of gravity¹
AD 1 to 2025



¹ Economic center of gravity is calculated by weighting locations by GDP in three dimensions and projected to the nearest point on the earth's surface. The surface projection of the center of gravity shifts north over the course of the century, reflecting the fact that in three-dimensional space America and Asia are not only "next" to each other, but also "across" from each other.

SOURCE: McKinsey Global Institute analysis using data from Angus Maddison; University of Groningen

Some actionable insights

- From individuals → communities
 - Find & learn from startups in population health
 - Explore ways to tap into social networks
- From diseases → disease networks
 - Closely monitor advances in molecular biology
 - Anticipate how new understanding might change risk pools
- From technical → sociotechnical
 - Play out scenarios around social/cultural implications of tech
 - Look for new business models & platforms
 - Combinatorial innovation!