TACOS
The Arizona Clinical Oncology Society

Strategies for Managing the Tsunami of Medical Information: AI and Beyond

April 22, 2023

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Medical Director of Radiation Oncology, Milton S. Hershey Medical Center Hershey, Pennsylvania

President, ACCC 2022-2023

PennState Health

Disclosures

Name	Employment	Funding Sources	Ownership & investments	Leadership
David R. Penberthy, MD, MBA	Penn State Health AstraZeneca Startups and Real Estate	None	CHS stock Mutual funds Startup - ROMTech	ACCC Board of Trustees

I would like to acknowledge

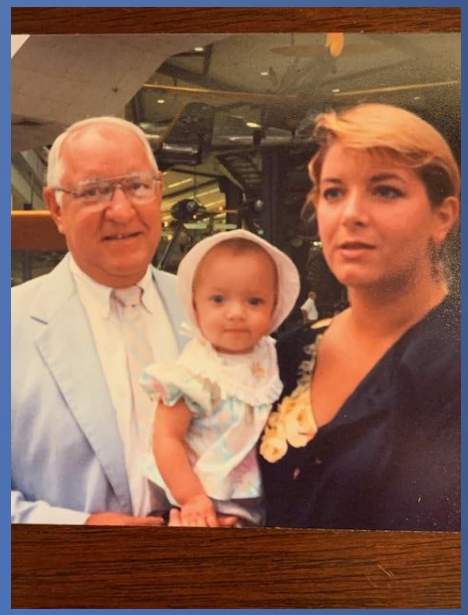
K. Singh Sahni, MD
Alfred M. Strash, PhD
Faye Flemming RN, BSN, OCN
Tracey Tatum, RN, NP
Cliff Robinson, MD
Peter Diamandis, MD
Matt Devino, MPH
Mark Liu, MPH
Amy Ellis, RN
Douglas Flora, MD
Sarah McGough, PhD
John Frownfelter, MD, FACP
Rick Baehner, MD
Blythe Adamson, PhD, MPH
Kevin Davies, PhD
Michael Dake, MD
Ryan Langdale

for their assistance with this presentation

Learning objectives

- A little about my background
- Statement of the worldwide and local cancer problem
- Current state of multidisciplinary care
- Future directions and AI!

Navy times ☺



The Magnitude

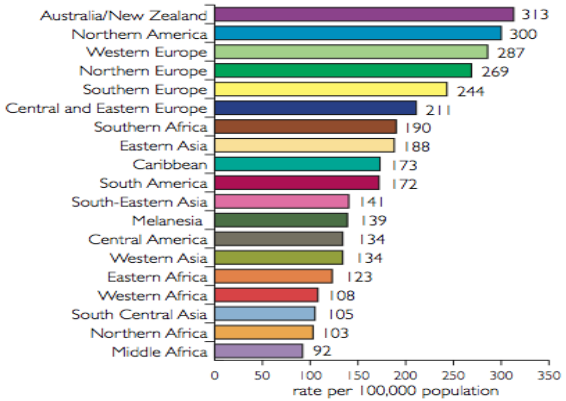
CANCER RESEARCH UK

International Agency for Research on Cancer

World Health Organization

Cancer Incidence Worldwide

Breakdown of the estimated 12.7 million new cases, World-age standardised incidence rates and the most commonly diagnosed cancers by the different regions of the world, 2008.



Northern America
Numbers 1,603,870
Lung 15%
Prostate 13%
Breast 13%
Colorectum 11%

Western Europe
Numbers 1,029,993
Prostate 16%
Breast 14%
Colorectum 13%
Lung 11%

Northern Europe
Numbers 482,080
Breast 15%
Prostate 13%
Colorectum 13%
Lung 12%

Central and Eastern Europe
Numbers 983,408
Lung 14%
Colorectum 13%
Breast 12%
Stomach 7%

Southern Europe
Numbers 713,401
Colorectum 14%
Breast 13%
Lung 12%
Prostate 11%

Eastern Asia
Numbers 3,720,658
Lung 17%
Stomach 16%
Liver 13%
Colorectum 10%

Northern Africa
Numbers 164,350
Breast 17%
Lung 7%
Bladder 7%
Non-Hodgkin lymphoma 7%

Caribbean
Numbers 79,347
Prostate 20%
Breast 11%
Lung 11%
Colorectum 9%

Western Africa
Numbers 184,071
Breast 16%
Cervix uteri 16%
Liver 11%
Prostate 7%

Western Asia
Numbers 223,042
Breast 13%
Lung 12%
Colorectum 8%
Stomach 7%

South-Eastern Asia
Numbers 725,446
Lung 14%
Breast 12%
Liver 10%
Colorectum 9%

Central America
Numbers 176,564
Prostate 12%
Breast 10%
Cervix uteri 9%
Stomach 8%

Middle Africa
Numbers 66,895
Liver 16%
Breast 12%
Cervix uteri 12%
Prostate 6%

South-Central Asia
Numbers 1,423,213
Cervix uteri 12%
Breast 12%
Lung 7%
Lip, oral cavity 7%

Melanesia
Numbers 7,028
Lip, oral cavity 12%
Cervix uteri 10%
Breast 9%
Liver 7%

South America
Numbers 650,097
Breast 14%
Prostate 13%
Lung 8%
Colorectum 7%

Southern Africa
Numbers 79,179
Breast 11%
Prostate 10%
Oesophagus 9%
Cervix uteri 8%

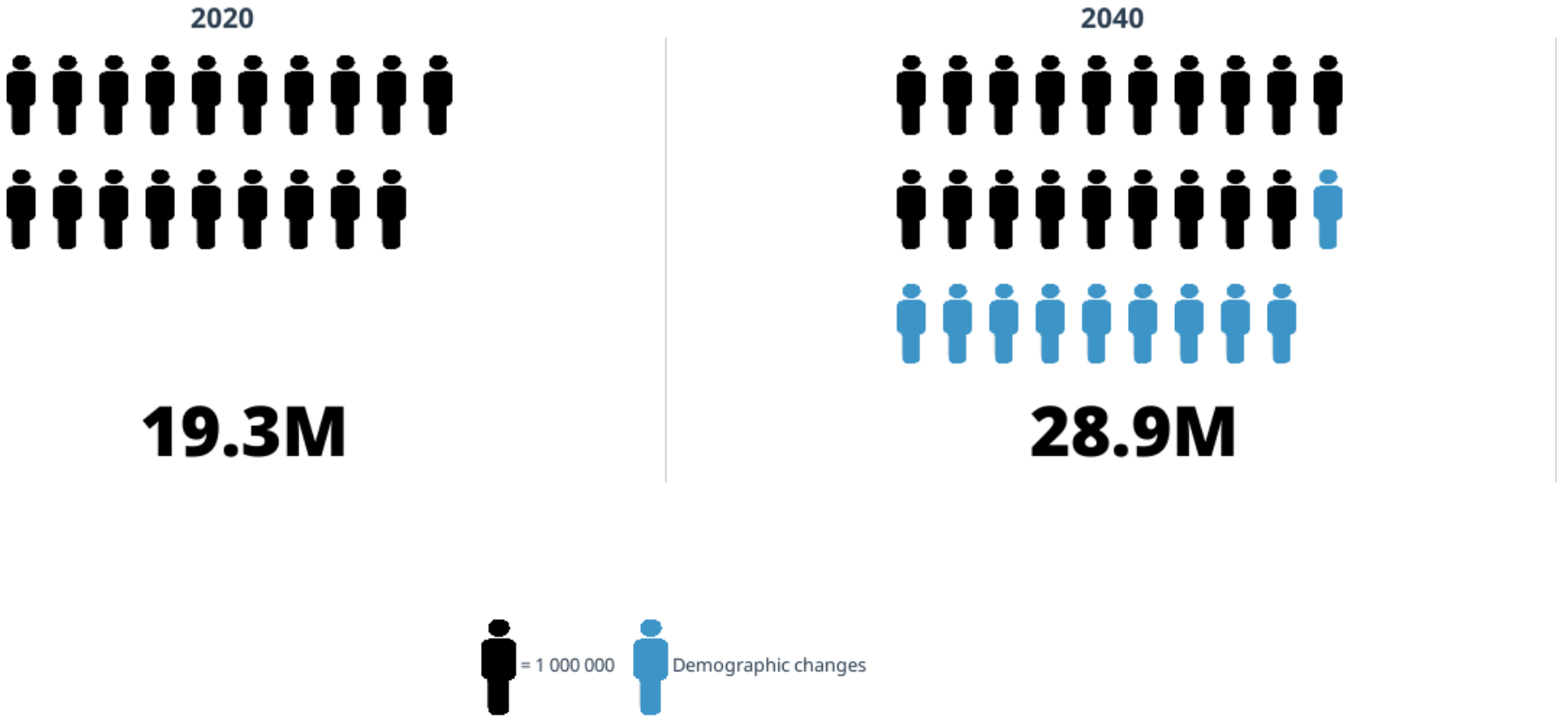
Eastern Africa
Numbers 221,076
Cervix uteri 14%
Kaposi sarcoma 11%
Breast 8%
Oesophagus 7%

Australia/New Zealand
Numbers 127,022
Prostate 17%
Colorectum 14%
Breast 13%
Melanoma of skin 11%

Source: GLOBOCAN 2008, v. 1.2, Cancer Incidence and Mortality Worldwide. IARC, 2010 (http://globocan.iarc.fr)
Map updated February 2011

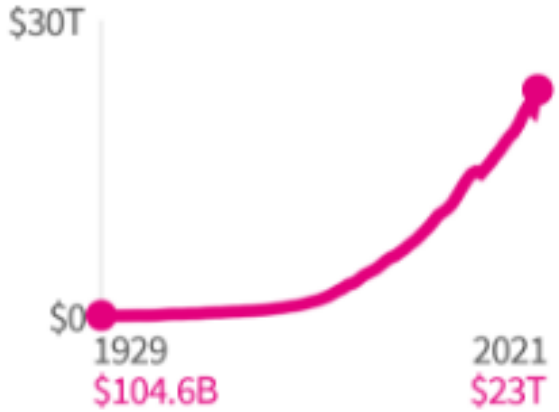
http://info.cancerresearchuk.org/cancerstats/

Estimated number of new cases from 2020 to 2040, Both sexes, age [0-85+]
All cancers
Africa + Latin America and Caribbean + Northern America + Europe + Oceania + Asia



International Agency for Research on Cancer
World Health Organization

GDP issues

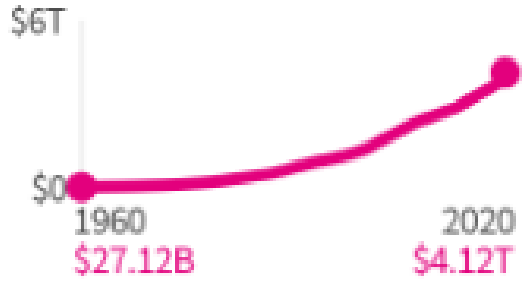


Gross domestic product

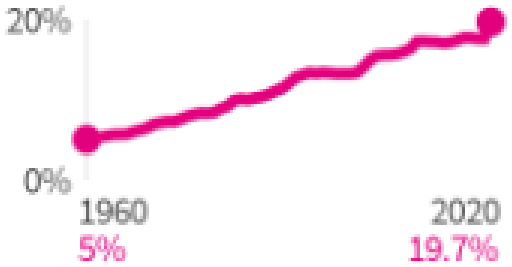
$23 trillion

2021

National spending on healthcare goods and services



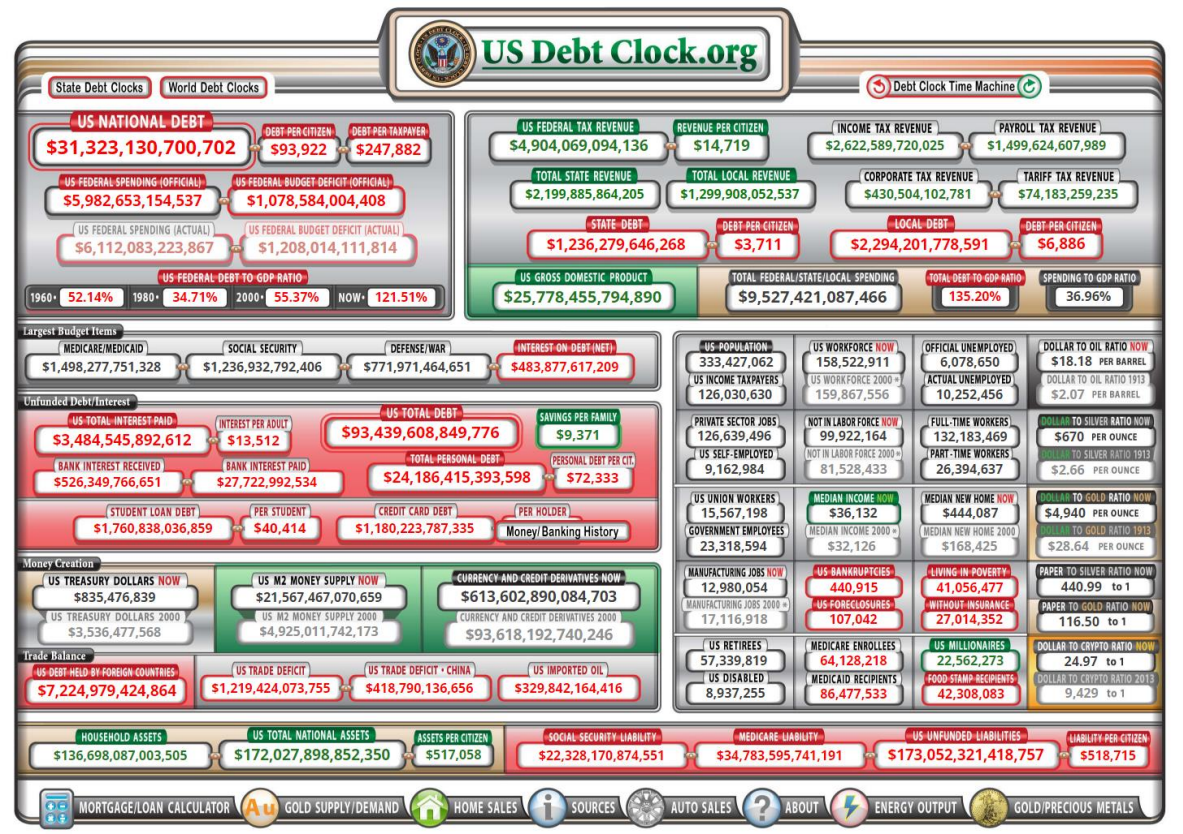
Healthcare expenditures as a percent of GDP

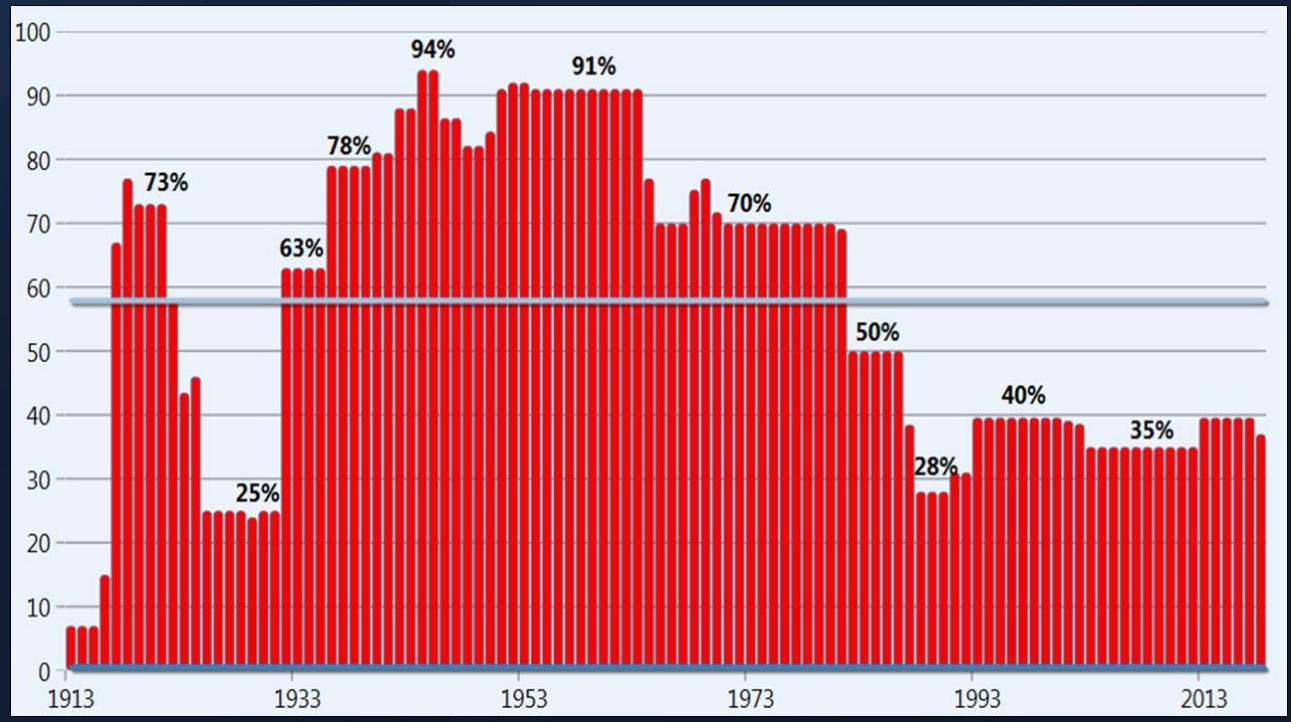


National debt $31T and counting

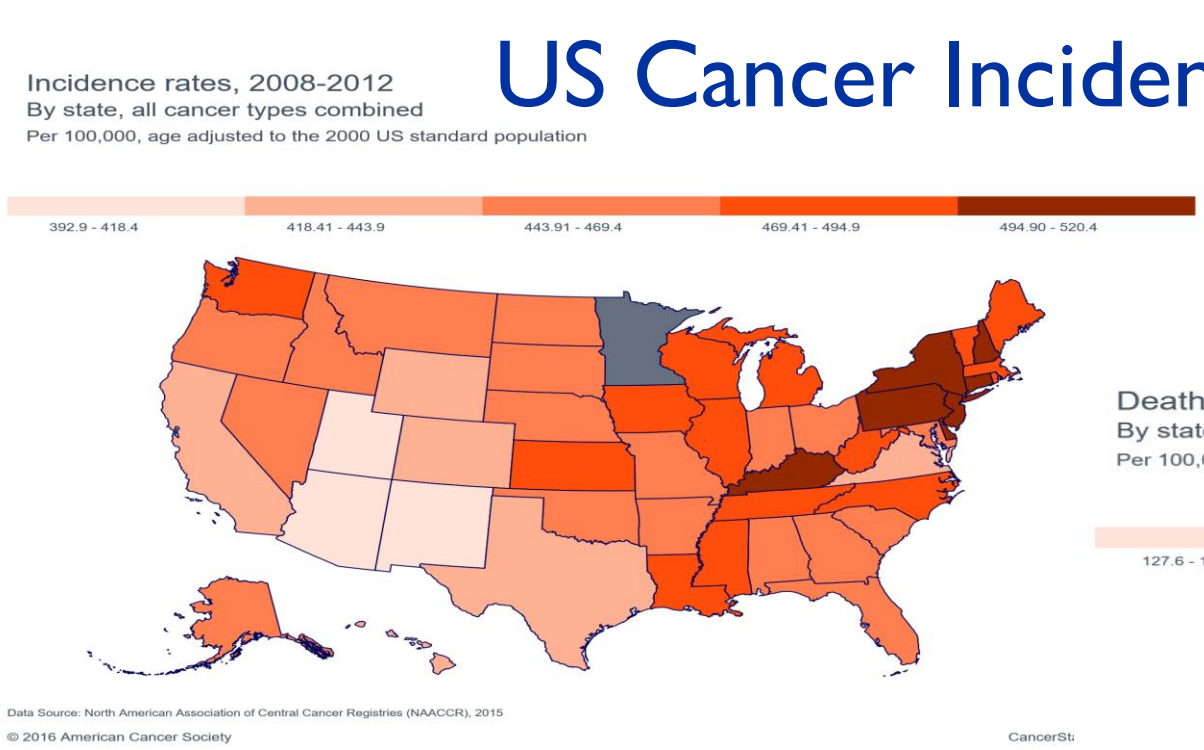
www.usdebtclock.org

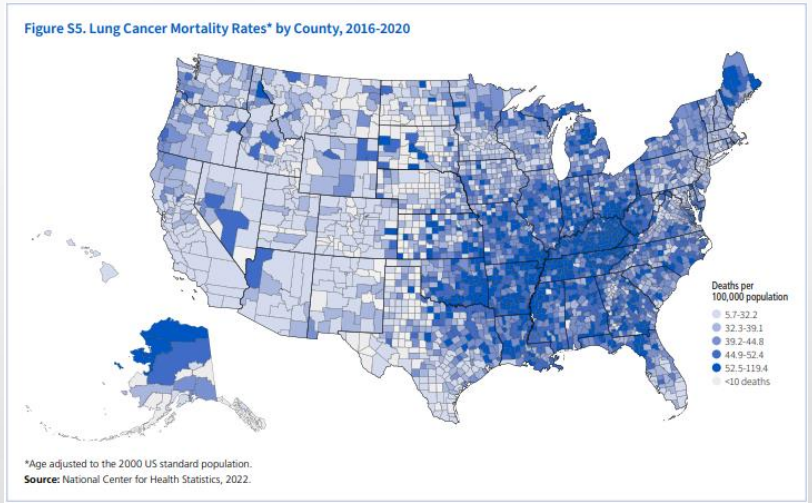
US Debt and Taxes

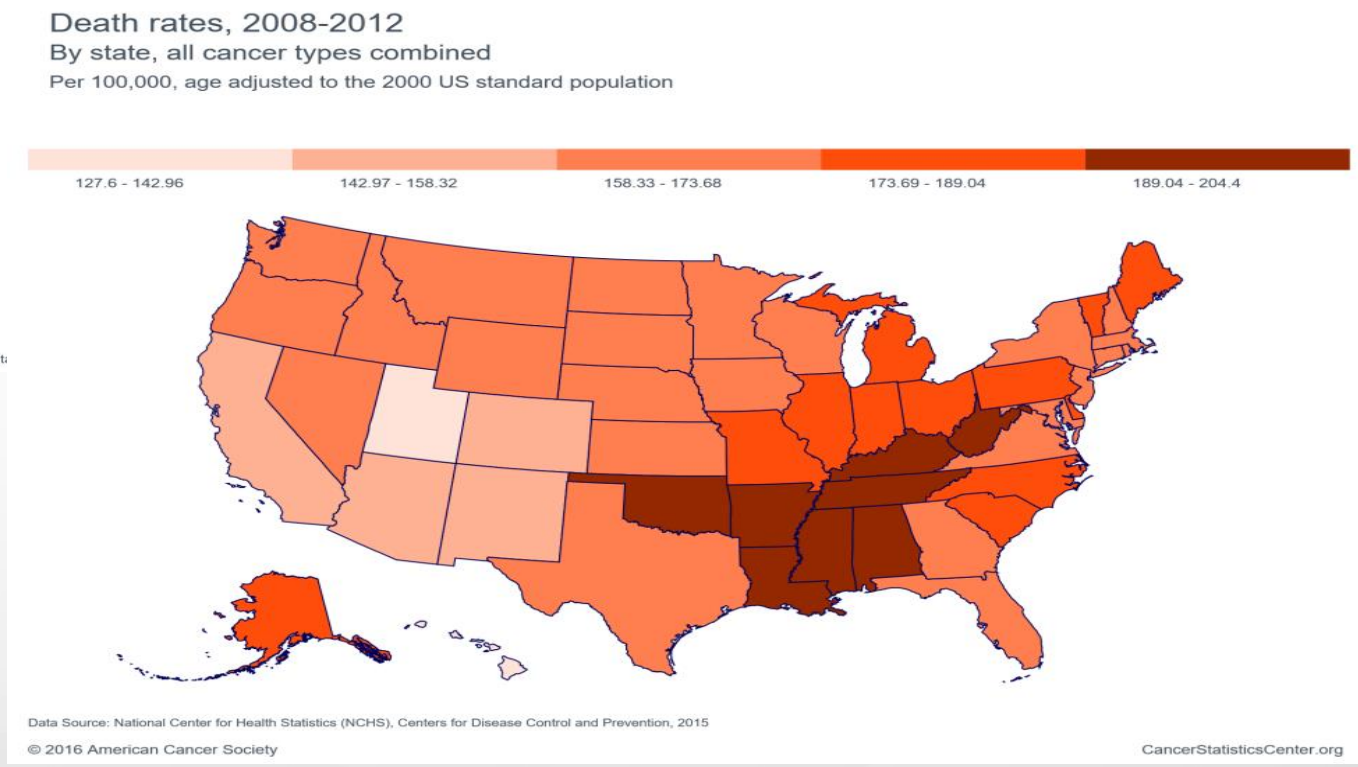




US Cancer Incidence and Mortality

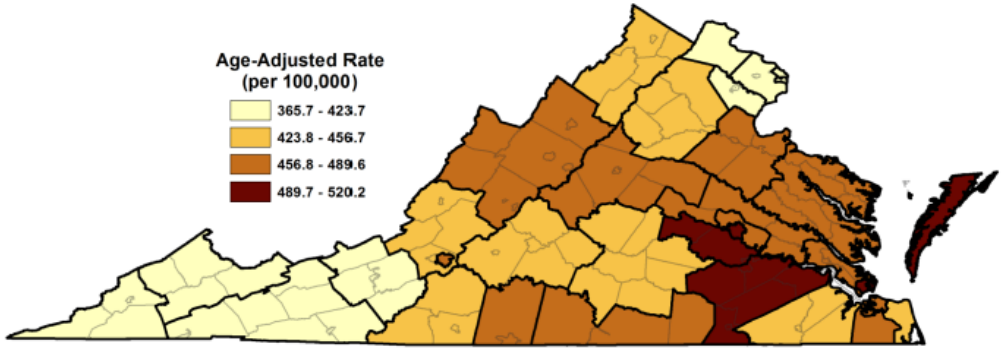






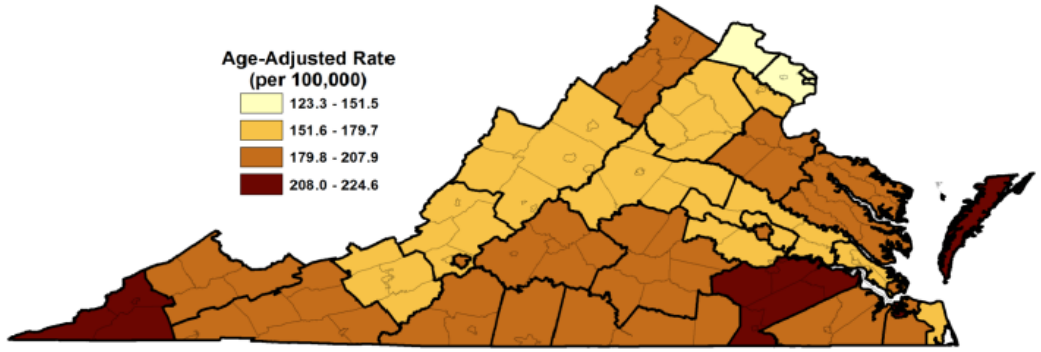
BON SECOURS MERCY HEALTH

Map 1.1: All Sites Cancer Incidence Rates by Health District, 2007-2011[1]



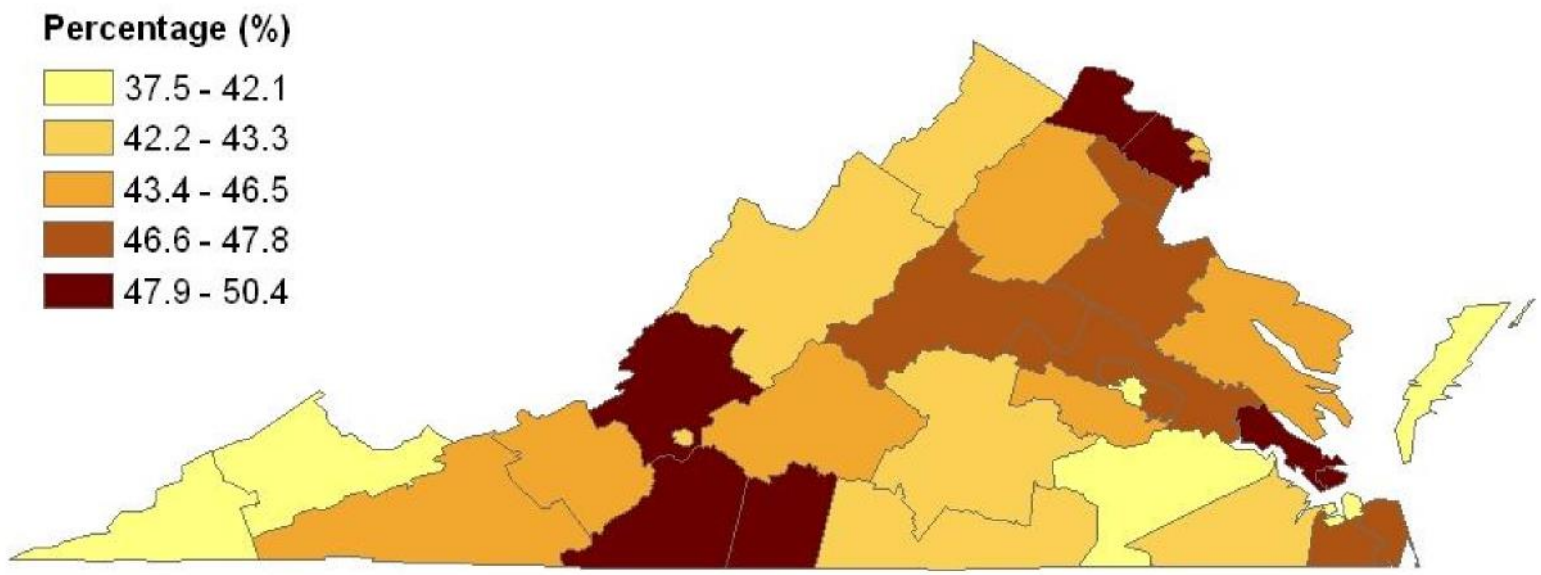
Eastern Shore (520.2 cases per 100,000), Hampton (512.8), and Chesterfield (504.6) had the highest all sites cancer incidence rates among the 35 health districts. Alexandria (365.7), Loudoun (387.2), and Cumberland Plateau (387.5) had the lowest incidence rates.

Map 1.2: All Sites Cancer Mortality Rate by Health District, 2008-2012[2]



Portsmouth (224.6 deaths per 100,000), Lenowisco (212.4), and Crater (210.7) had the highest mortality rates from all sites cancer among the 35 health districts. Alexandria (123.3), Arlington (126.2), and Fairfax (131.5) had the lowest mortality rates among the 35 health districts.

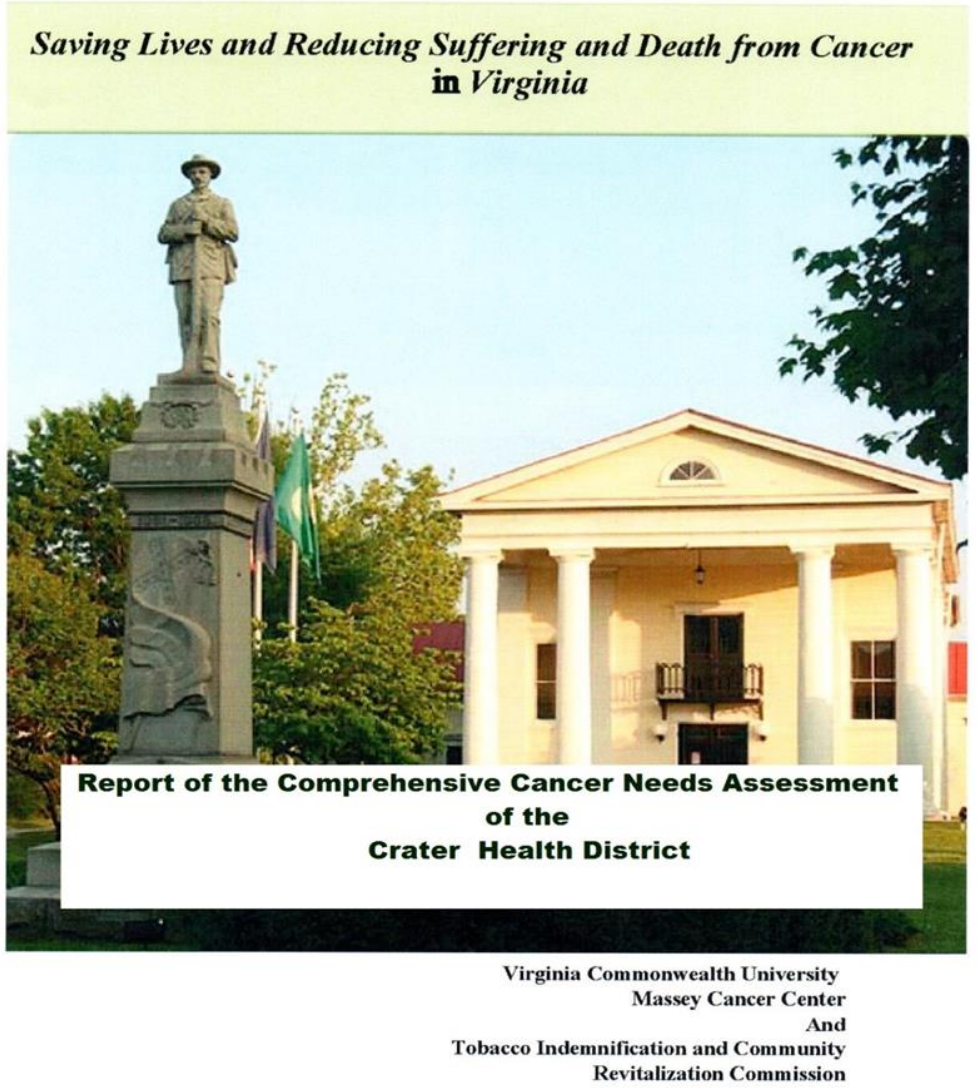
Percentage of Cancer Cases Diagnosed at Local Stage by Health District, All Sites, Virginia, 2003-2007



Source: Virginia Cancer Registry, Virginia Department of Health.

Comprehensive Cancer Needs Assessment

- Partnered with VCU Massey Cancer Center and the Tobacco Indemnification and Community Revitalization Commission



SRMC Oncology Service Line Development

SRMC senior leadership & corp. commitment to provide quality oncology care within our community

1/6/2009 - 12/31/2014
SRMC Oncology Accomplishments

2009

- ***Decision** to develop an SRMC Oncology Service Line
- ***Oncology** Service Line Director position approved and advertised

2010

- ***Oncology** Service Line Director hired
- ***Ca.** Committee reorganized
- ***Oncology** Steering Committee
- ***CoC** accreditation prep
- ***Support** groups & activities
- ***Massey/NCI's** comprehensive community ca needs assessment project participation
- ***Oncology** consultants
- ***Physician** needs assessment
- ***Physician** re-alignment with ca program
- ***SRMC** Ca program & activities assessment

2011

- ***Psychosocial** support & program planned
- ***ACCC** Innovator Award for Oncofertility
- ***VA** Radiation Oncology Associates
- ***David** Penberthy, MD Medical Director
- ***Navigation** program planned
- ***Nurse** navigator recruited
- ***Oncology** Quality Committee
- ***Ca** conferences restructured
- ***CoC** accreditation with commendation
- ***CoC** Outstanding Achievement Award

2012

- ***Psychosocial** program
- ***Nurse** Navigator
- ***Navigation** program
- ***Good** Neighbors psychosocial partnership
- ***Survivorship** software with SRMC psychosocial & navigation customization
- ***ARIA** Rad Onc upgrades
- ***Rad** Onc CT
- ***Ca** conferences wkly
- ***Palliative** care task force
- ***Survivorship** tx plans & care summaries
- ***SRMC** med onc practice
- ***SRMC** infusion center
- ***Chemo/** biotherapy task force
- ***Pre-printed** chemo/ biotherapy orders
- ***Oncology** PhD Pharmacist
- ***Ground** breaking

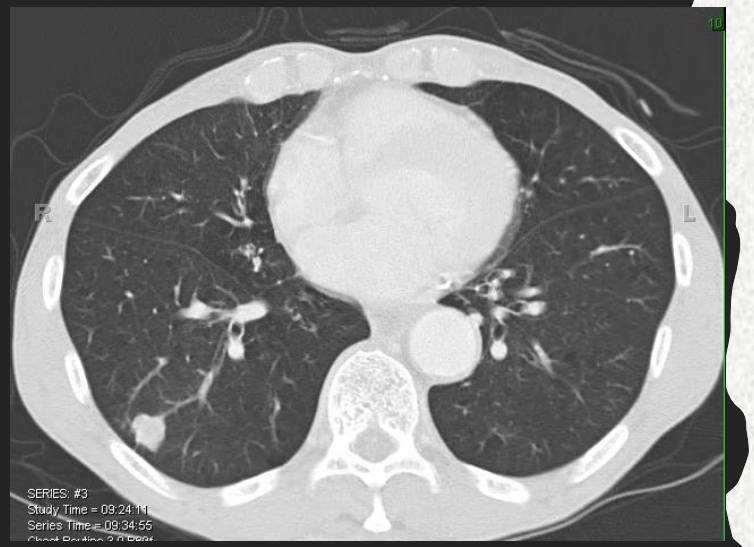
2013

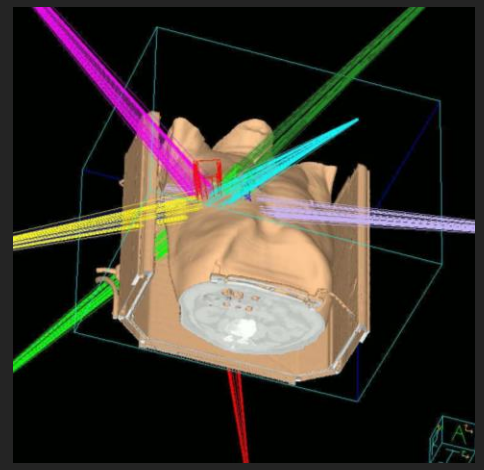
- ***Commonwealth** Laboratory Consultants
- ***John** Summerville, MD Medical Director Pathology
- ***Cancer Center** planning & construction
- ***Beta** testing site for software upgrade to include navigation
- ***Distress** mgmt program electronic documentation
- ***Community** Advisory Group
- ***Fine** tuned 2012 programs and services

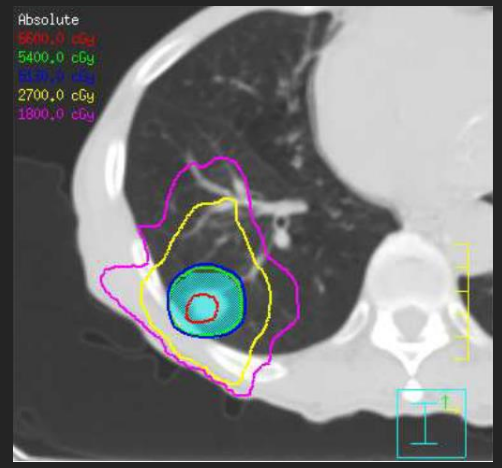
2014

- ***Rad** Onc moved to hospital campus
- ***Cancer** Center opened
- ***True** Beam linac
- ***Virginia** Ca Institute
- ***Closed** SRMC med onc practice
- ***Closed** SRMC infusion center
- ***SRS** CON
- ***HDR** CON
- ***2nd** True beam (with SRS)
- ***CoC** cancer program re-accreditation (in progress)

Convincing my admin to invest in SBRT tech

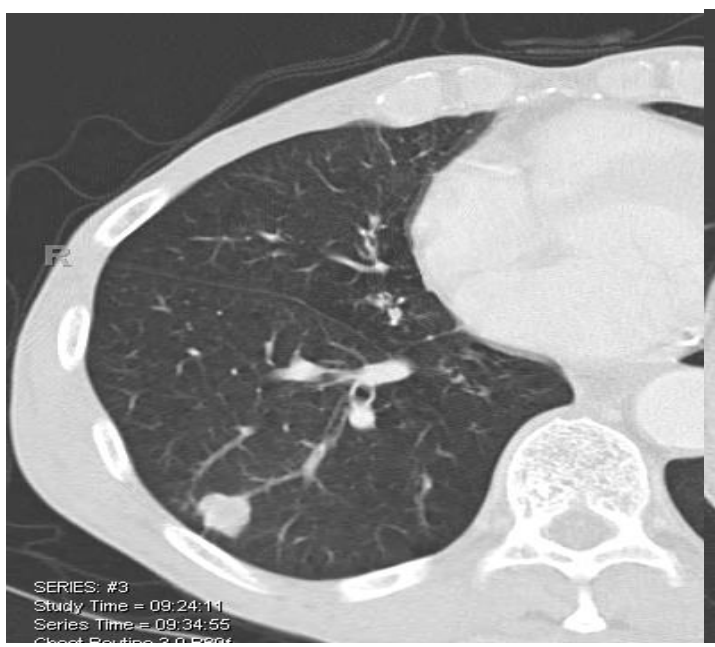




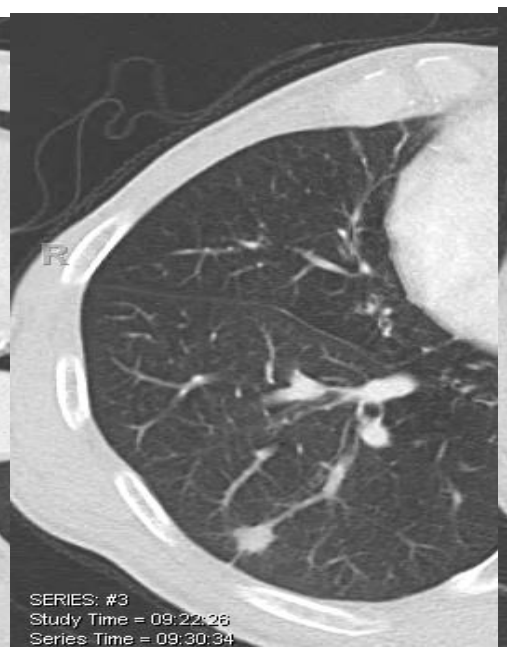


Local Control

October 2009



January 2010



October 2011

Under construction

Bon Secours Southside Medical Center

Petersburg, Virginia

SRMC proudly announces

Cancer Program

Accreditation with Commendation

and 2011 Outstanding Achievement Award

SRMC
SOUTHSIDE REGIONAL
MEDICAL CENTER

Commission on Cancer®
ACCREDITED PROGRAM

Bon Secours Southside Medical Center

- Formerly Owned by Community Health Systems, Inc. (CYH)
  - 127 hospitals in 20 states, ~21,000 licensed beds
  - ~30 Radiation Oncology programs (organizationally structured under Imaging Services)
  - Acquired by Bon Secours Mercy Health, finalized January 1, 2020
- BS-SMC is a 300 bed hospital with a Comprehensive Community Cancer Program with >500 newly diagnosed cases per year
- Accredited by American College of Surgeons Commission on Cancer earning Gold-Level Commendation and Outstanding Achievement Award for 2 of the past 3 survey cycles

Bon Secours Mercy Health by the numbers

ONE OF THE 5 LARGEST
Catholic health care systems in the US,
the LARGEST private provider in Ireland

MORE THAN **1,200** SITES OF CARE IN THE US AND IRELAND

Approximately **$10 BILLION**
in pro forma net operating revenue

MORE THAN **$2 MILLION** A DAY
IN COMMUNITY BENEFITS

50 HOSPITALS

2,600 PROVIDERS IN THE US
450 CONSULTANTS IN IRELAND
60,000 TOTAL ASSOCIATES

BON SECOURS MERCY HEALTH

Advanced cancer care requires Multidisciplinary treatment

Institutional support

- - Nurses
- - Medical Physicists
- - Radiation Oncologist
- - Medical Oncologist
- - Neurosurgeons
- - Thoracic surgeon
- - General surgeon
- - Radiologist
- - Pathologist
- - Pharmacist, et al.

Advanced cancer care requires oncology patient, family and community support

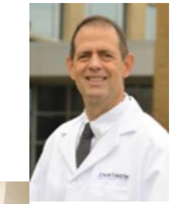
- **Oncology Service Line**
- - Psychosocial program
- - Navigation program
- - Distress management program
- - Survivorship plans & care
- - Palliative care task force
- - Oncology research collaborations
- - Genetic testing & referrals
- - Community outreach program
- - Oncofertility resources

All about the people







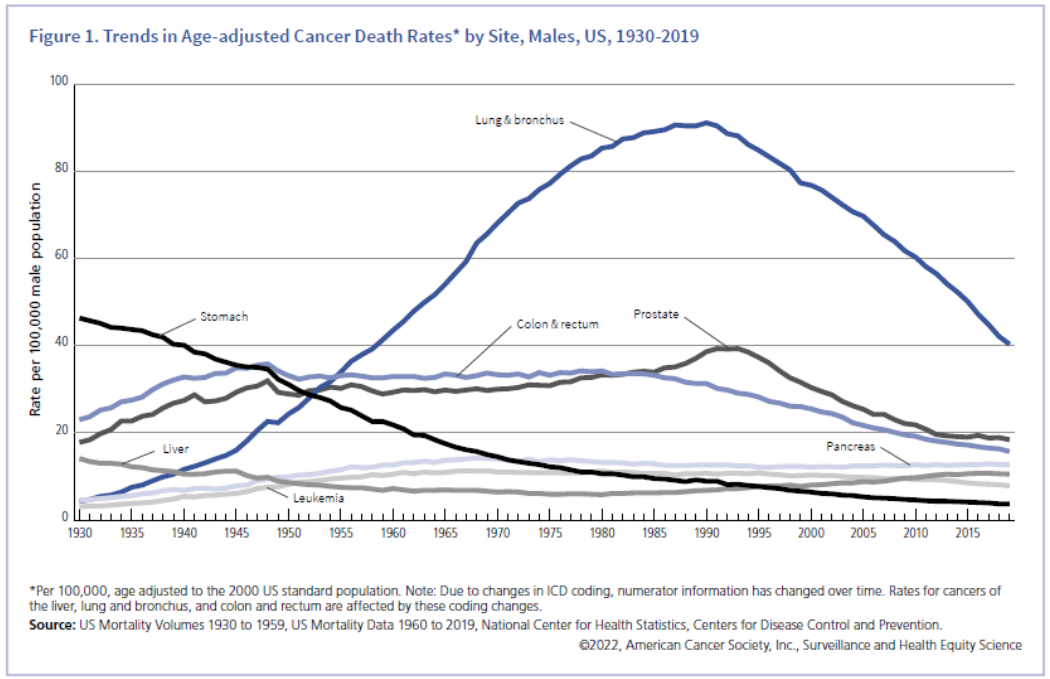


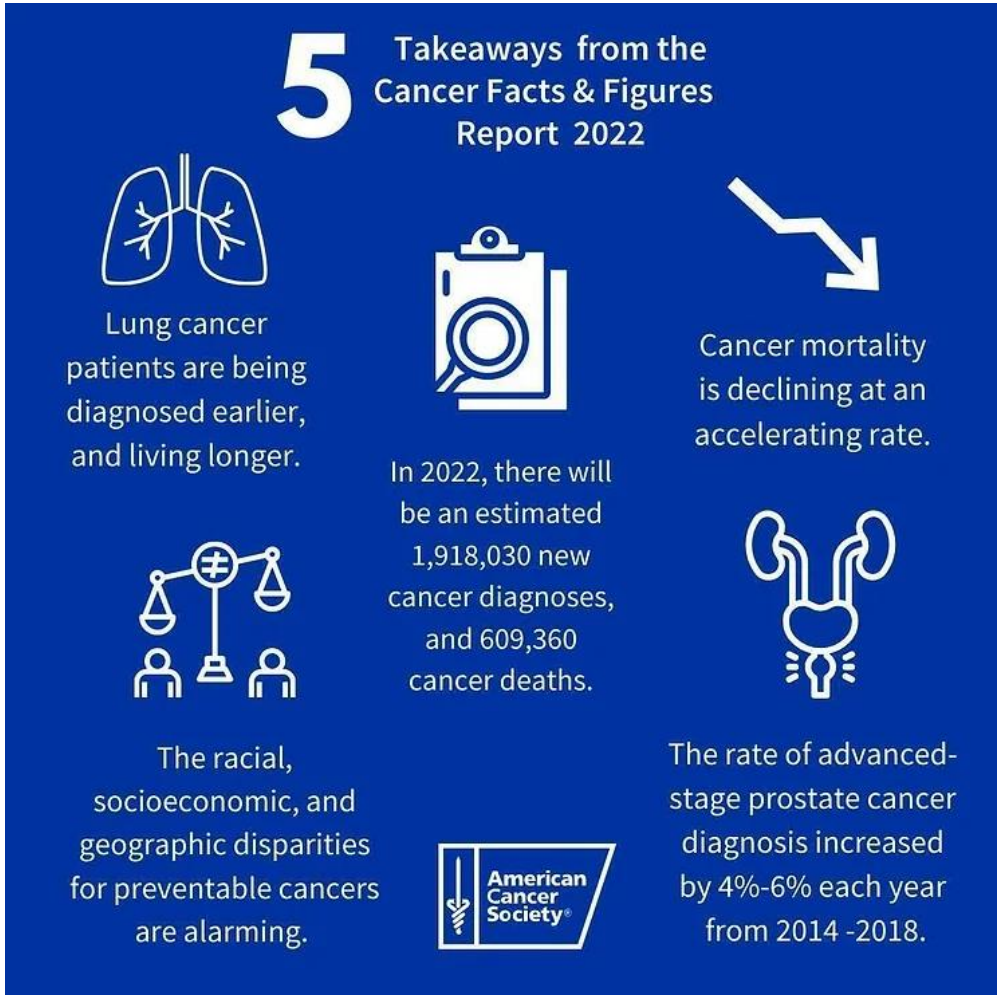







So how are we doing?





ASSOCIATION OF COMMUNITY CANCER CENTERS

LEADING EDUCATION AND ADVOCACY ORGANIZATION FOR THE CANCER CARE COMMUNITY

- ~50 years old (founded 1974)
- Powerful network of ~30,000 multidisciplinary practitioners from over 2100 hospitals and practices nationwide
- ~2/3 of the nation's cancer patients are treated by a member of ACCC
- Presidential Theme – "Leveraging Technology to Transform Cancer Care Delivery and the Patient Experience"
- www.accc-cancer.org

Future Concepts

THE CHALLENGE

Daily: It's estimated that around 4,000 new articles are added to PubMed each day. This number is not limited to original research but also includes reviews, case reports, and other types of articles.

Weekly: With approximately 4,000 articles added daily, we can estimate that around 28,000 new articles are published weekly.

Monthly: Using the same daily estimate, approximately 120,000 new articles are published per month

Yearly: Annually, the number of new articles published can be roughly estimated at 1.44 million (4,000 daily publications multiplied by 365 days).

These figures only represent a fraction of the medical information being generated, as they do not account for other sources like clinical trials, patents, guidelines, conference proceedings, and more. Additionally, the growth of data in fields like genomics and digital health is further accelerating the expansion of medical information.

ONCOLOGY LITERATURE

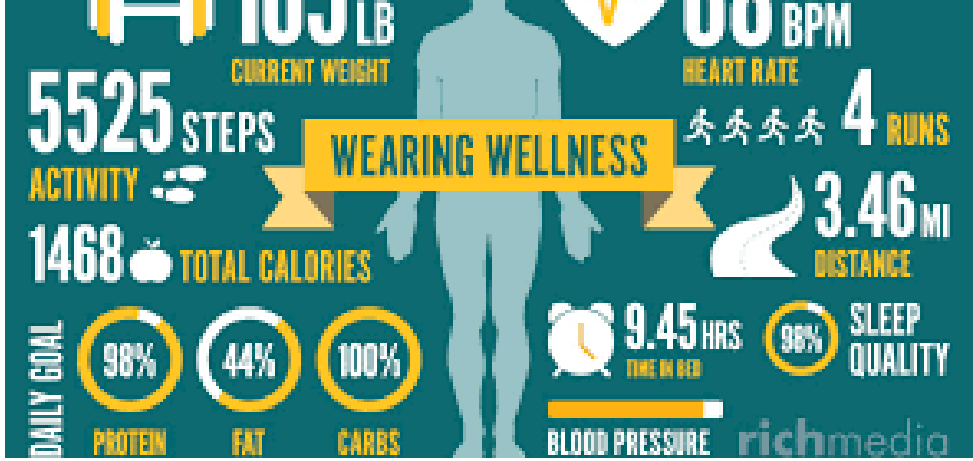
About 10% of published medical literature relates to oncology

Daily - 400 oncology related articles

Weekly - 2800 oncology related articles

Monthly – 12,000 oncology related articles

Yearly - 144,000 oncology related articles



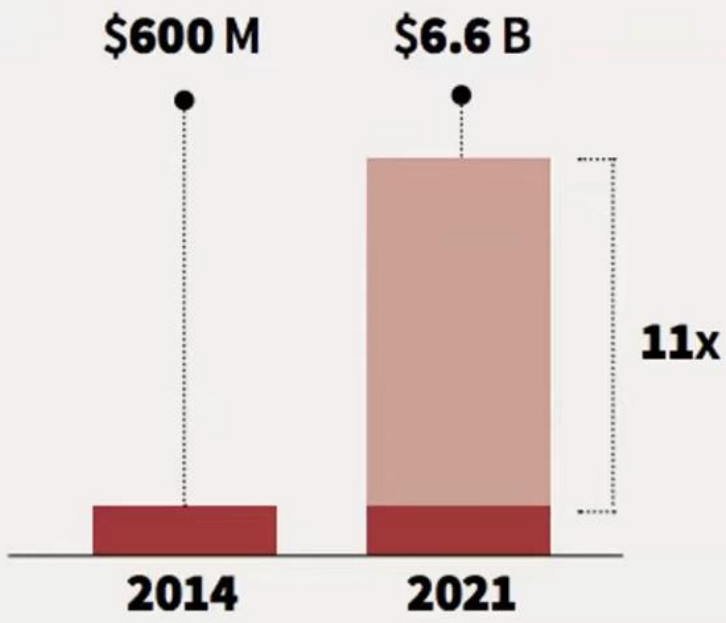
Google™

HEALTH

LEVERAGING TECHNOLOGY

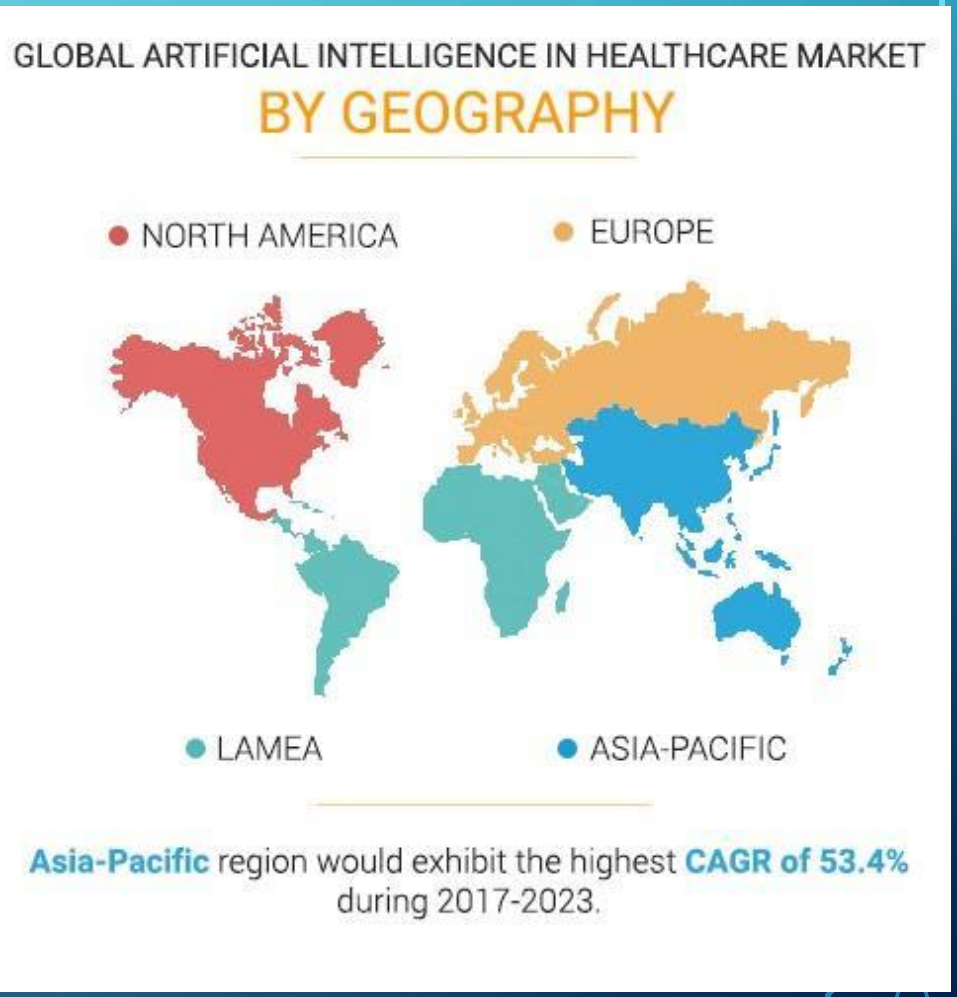
STRATEGIES FOR MANAGING THE TSUNAMI OF MEDICAL INFORMATION: AI AND BEYOND

Health AI Market Size 2014 - 2021



Acquisitions of AI startups are rapidly increasing while the health market is set to register an explosive CAGR of 40% through 2021.

Source: Accenture (December 2017). Artificial Intelligence in Healthcare.



AI in Healthcare

Patient-Facing

AI Chatbots

buoy, Your.MD, medwhat, GYANT, Dr.AI

Wearables & Devices

physIQ, QARDIO, sano, QUANTTUS, DietSensor, kiwi.ai, BIOSERENITY, Jodytrak, Magnea, kinsa, SCANADU, aira, AliveCor, 19 Labs, CliniCloud

Personalized Genetics

iCarbonX, rthm, CG, DAY TWO, Positive, LIFENOME, MEDICUS, 23andMe, VIAGENE, Arivale, habit, Suggestic, VIOME

Mental Health

Woebot, TOUCHKIN, BIOBEATS, Ginger.io, NeuroLex, AURA, koko

Women's Health

CYRCADIA HEALTH, bloomlife, celmatix, flutter, eva, Clue, elyse, Natural Cycles

Skin

SkinVision, skinIO, skin analytics, SCANZ, skin, DOCTOR HAZEL, FIRST DERM

Telehealth

Telemedicine

ada, SENSELY, how are you feeling today?, babylon, anamnèse, Remedy, pager, spruce

Lifestyle Management

AiCure, MedAware, ovia health, next IT, Catalia Health, Healthcare lucina, Health Next Gen, Doctella, NarrativeDx, cardiogram, Wellframe, Welltok, CareAngel

Disease Management

prognos, INFOBIONIC, HealthReveal, HEALTH FIDELITY, DIABNEXT, SENTRIAN, FLASHBACK TECHNOLOGIES, TEMPUS, dreamed, Healint, WIKAYA, RxPREDICT, BELONG

Research

Drug Discovery

Mind the Byte, SaaS for Drug Discovery, DATAVANT, Quantitative Medicine, Standigm, BERG, RECURSION, ENVISAGENICS, BenevolentAI, Athelas, Exscientia, NuMedii, healx, transcriptic, Numerate, twoXAR, Atomwise, Better medicines faster., Globavir, CloudPharmaceuticals

Information & Clinical Trials

trials.ai, PathAI, BenchSci, CYCLICA, Mendel.ai, Qrativ, peptone, Brite Health, iQLEXUS, antidote, Plex Research, nference, RESULTCARE

Genetic Research

MolecularMatch, Blueprint Genetics, VERGE GENOMICS, NURITAS, diploid, HUMAN LONGEVITY, INC., SOPHIA GENETICS, freenome, FDNA, PATHWAY GENOMICS, deep genomics, DESKTOPGENETICS

Doctor-Facing

Medical Records

APIXIO, AUGMEDIX, clinithink, MODERNIZING MEDICINE, nimblr, saykara, emr.ai, WellSheet, hCue, patientory, SANSORO HEALTH, PROTENUS, BloomAPI

Data Analytics

ZEPHYR HEALTH, burstIQ, MD.ai, Infermedica, CLOUDMEDX, jvion, CareSkore, flatiron, PROFILITY, lumiata, ROAM, Hindsait, Oncora MEDICAL, GRAIL, MEDALOGIX, ensodata, pulseData, healthcare.ai, KenSci, COMBINOSTICS, impacthealth, LYTICS

Medical Imaging

VIZ, AMARA HEALTH ANALYTICS, enlitic, zebra MEDICAL VISION, 推想科技 infervision, CureMetrix, BAYLABS, VUNO, ADVENIO, Transpiring Innovation, koios, BUTTERFLY Network, Inc., SIGTUPLE, Behold.ai, imagia, ARTERYS, IMAGEN, Mindshare MEDICAL, aidence, aidoc, Lunit, Cardiologs, Genetesis, HubMedX, DIA, SemanticMD, Blackford analysis

Hospital

FORWARD, Qventus, MedyMatch, gauss, o-rg-o.ai, MEDASENSE, P3d, AURIS, VERB SURGICAL, Qualaris

90+ Healthcare AI Startups To Watch

Imaging & Diagnostics

ablacon, aidence, aidoc, Healthy.io, PathAI, RadiomicsAI, Aillis, 推想科技 infervision, sight, enlitic, freenome, zebra, BUTTERFLY Network, Inc., IBEX, IDx, SIGTUPLE, ULTROMICS, PAIGE, VUNO, VoxelCloud, Lunit, VIZ

Drug Discovery

Accutar Biotech, BenevolentAI, FINCH THERAPEUTICS, APEIRON, BlackThorn THERAPEUTICS, Frontier MEDICINES, insitro, Atomwise, Exscientia, engine, JUVENESCENCE, Notable Labs, OWKIN, RECURSION, 药研社, Standigm, XtalPi, twoAR, SPRING DISCOVERY

Predictive Analytics & Risk Scoring

BenchSci, 森亿智能 SYNYI·AI, saama, GNS HEALTHCARE, Medial EarlySign, TEMPUS, ikioo, medopad, Welltok, nference

Genomics

DECIPHER BIOSCIENCES, SOPHIA GENETICS, Syntekabio, WuXiNextCODE

Fitness

FINC

Virtual Assistant

babylon, Curai, mfine, notable, buoy, Suki

Hospital Decision Support

binaryfountain, Cardinal Analytx Solutions, Qventus, gauss, Olive, OM1, KenSci, NextHealth TECHNOLOGIES, LeanTaaS, Medical INFORMATICS

Clinical Trials

deep, HEALTH[at]SCALE TECHNOLOGIES, teckro.

Nutrition

NURITAS, WHOLE BIOME

Remote Monitoring

biofourmis, ContinUse Biometrics, DENTAL MONITORING

Compliance

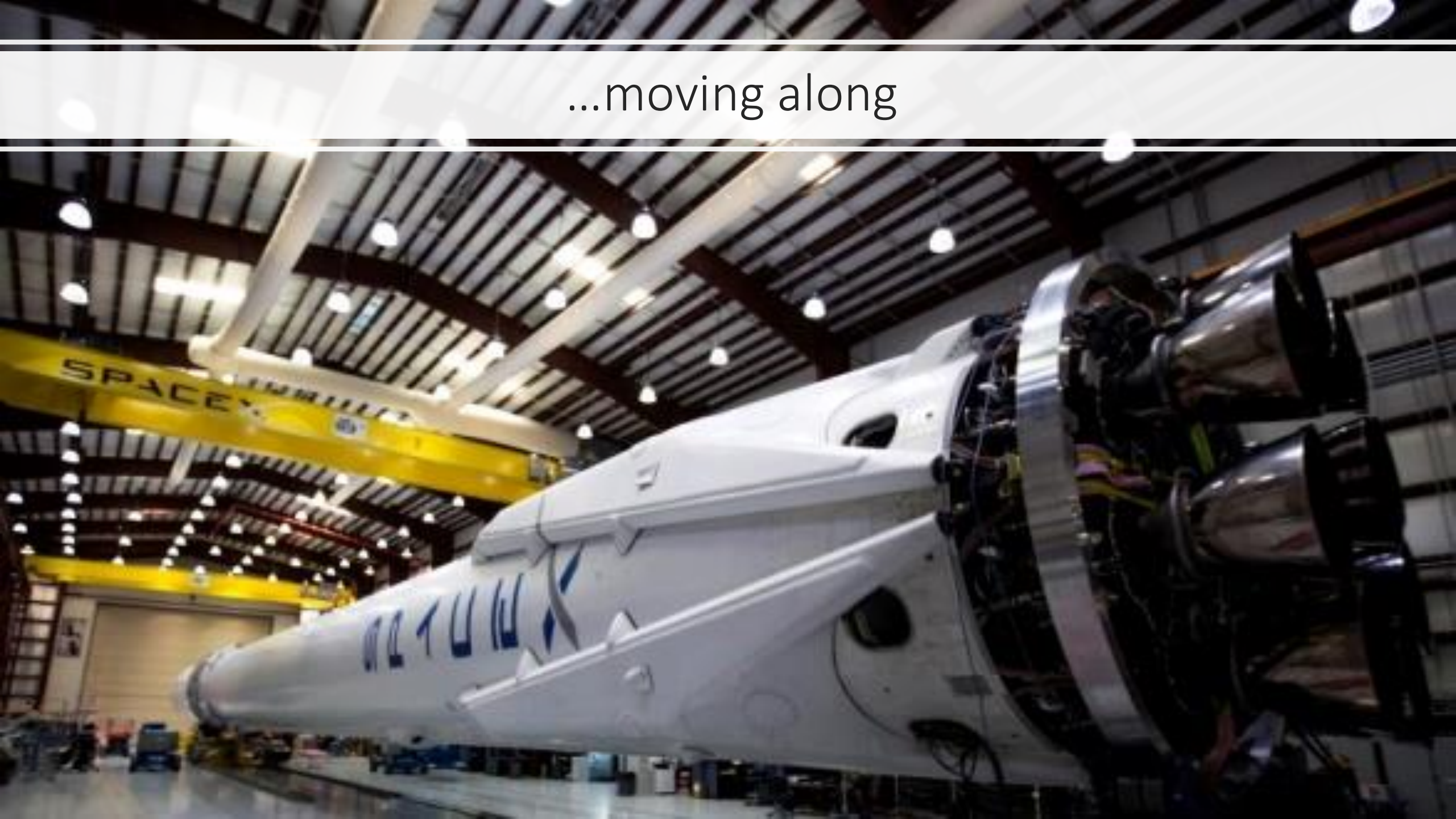
DATAVANT, PROTENUS

Mental Health

mindstrong

Created by You. Powered by CBINSIGHTS

…moving along



ACCC
Association of Community Cancer Centers

Digital Tools in Cancer Care

RPM Technologies Survey Findings

FULL REPORT

Advisory Committee

Amanda Dean Martin, DNP, CENP, ACNP-BC
Chief of Clinical Integration
Banner MD Anderson Cancer Center
Phoenix, AZ

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Chief Executive Officer
Highlands Oncology Group
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Director, Oncology Supportive Care
M Health Fairview
Minneapolis, MN

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Nurse Practitioner; Manager of Ochsner Precision Cancer Therapies Program
Ochsner Cancer Institute
New Orleans, LA

Anne Marie F. Rainey, MSN RN CHC
Director of Quality and Value-Based Care
Clearview Cancer Institute
Huntsville, AL

Ramy Sedhom, MD
Clinical Assistant Professor; Faculty, Penn Center for Cancer Care Innovation
Penn Medicine, Princeton Health
Princeton, NJ

Cardinale Smith, MD, PhD
Director of Quality for Cancer Services
Mount Sinai Health System
New York, NY

Sydney Townsend, MPAff, PMP
Director, Virtual Care
Texas Oncology
Austin, TX

Methodology

Patients and Caregivers:

Online survey (n=162)

- 90 cancer patients
  - currently undergoing treatment or treated in last 3 years
- 72 caregivers
  - caregivers to patients with cancer currently undergoing treatment or treated in last 3 years

Fielded January 4 – 23, 2023

Providers:

Online survey (n=128)

- Distributed by ACCC
- n=58 from SERMO
- N=70 from ACCC

Fielded December 21, 2022 – January 23, 2023

Methodological Limitations:

Potential sampling bias among patients & caregivers

- **1%** of sample had concerns around access to a smartphone or computer as a potential barrier

Subgroups for Analysis

Patients	Caregivers	Urban	Suburban	Rural	Patient age <65	Patient age 65+	Person of Color	Not POC
n=90	n=72*	n=45	n=83	n=34	n=65	n=97	n=63*	n=98

*Caregivers and persons of color skewed younger.

Providers	Community	Academic/NCI	Private	Admin	Physicians	Nurses	Urban	Suburban	Rural	Implemented/Implementing RPM	Considering/Planning/Pilot RPM	Not considering RPM
n=128	n=51	n=49	n=26*	n=23*	n=67	n=23*	n=74	n=38	n=16*	n=36	n=51	n=36

▲▼Denotes statistically significantly higher/lower than adjacent comparison group @90% CL
▲▼ Denotes statistically significantly higher/lower than adjacent comparison group @95% CL

*sample sizes below n=30 are considered extremely small and should be viewed with caution

Key Findings: Patients and Caregivers

1

Open to using digital tools to report symptoms

- Most patients and caregivers are **open to using technology to report symptoms** during cancer treatment
- More than half report either using technology already or considering its use
- **Caregivers are more likely to already use technology** to report symptoms and share symptoms that normally wouldn't come up during an appointment.

2

See the value in reporting symptoms

- Patients, caregivers, and providers agree that **keeping the healthcare team up to date and alerting if medical treatment is necessary** are the top reasons to use technology
- Providers also see improving outcomes and reducing hospitalizations as top benefits – a potential opportunity area to educate patients on additional benefits

3

Need in-person tech support and privacy/cost concerns addressed

- **Patients and caregivers feel that meeting in-person to help set-up technology is the most helpful**, particularly among rural and older respondents
- Patients and caregivers are **most concerned about the privacy of health data and cost of using technology**
- **Clear gap** between what patients want for technology support and what providers are offering

Key Findings: Cancer Programs

1

Concerns around confidence and accuracy

- While providers see benefits to RPM, they also **express only weak confidence in their own use of digital technology as well as cautious about the accuracy of data provided** by patients and caregivers
- Perceptions of benefits are lower among practices not considering RPM suggesting there is outreach and education to do

2

Admin as RPM advocates & disconnect between training and use

- **Admins appear to be greatest advocates for RPM –** encouraging adoption and expressing concern about patient accessibility
- Does not appear that training is happening consistently
- **While nurses are identified as key roles for monitoring RPM data, they report the least experience with it**

3

Great momentum and resulting need for RPM implementation support

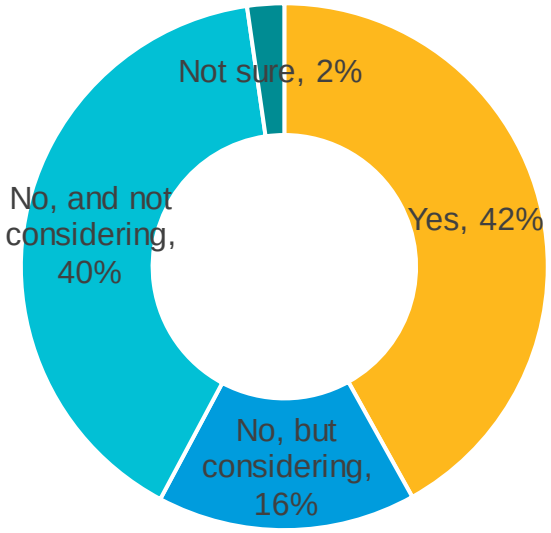
- **Most cancer programs (7 in 10) reported at least early planning for RPM, with 3 in 10 programs having already implemented the technology**
- Many are already using EHR patient portals and/or text messaging to communicate
- **Implementation support needed** includes strategies for funding/reimbursement, business case examples, training, and success stories.

Use of Technology

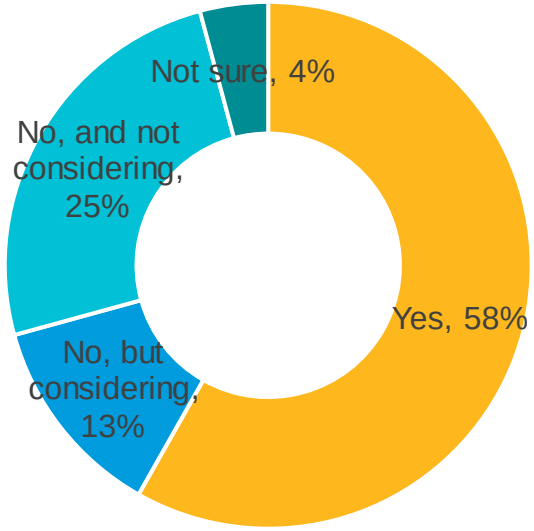
Across Patient, Caregiver, and Provider audiences, there are groups of respondents who have embraced technology and others who are not planning to adopt it.

Use Technology to Track Health Information During Cancer Treatment

Patients

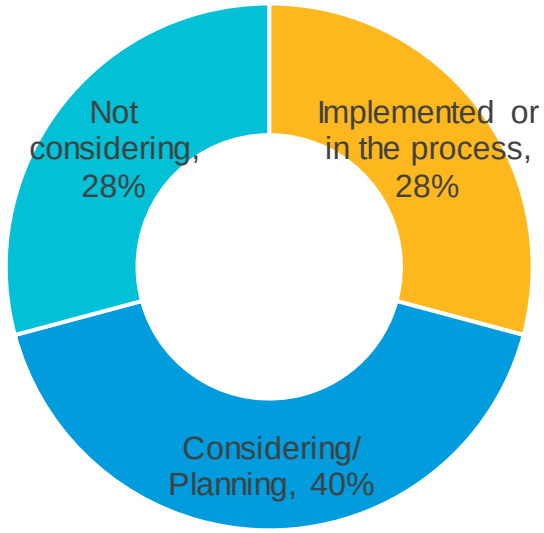


Caregivers



Program or Practice Involvement in Remote Patient Monitoring

Providers



ACCC 2022-2023 PRESIDENT'S THEME

Leveraging Technology to Transform Cancer Care Delivery and the Patient Experience

David R. Penberthy, MD, MBA
Associate Professor of Radiation Oncology
Penn State Health
Milton S. Hershey Medical Center
Hershey, Pa.

ASSOCIATION OF COMMUNITY CANCER CENTERS (ACCC)

ACCC 2022-23 President's Theme Tech Talk #1

The Home as a New Site of Cancer Care

Thursday, July 14, 2022

ASSOCIATION OF COMMUNITY CANCER CENTERS (ACCC)

ACCC 2022-2023 President's Theme Tech Talk #2

Technology Solutions to Mitigate the Workforce Shortage

Thursday, August 18, 2022

TECH TALK SPEAKERS

Amy Ellis
Chief Operating Officer
Northwest Medical Specialties, PLLC
Tacoma, Wash.

Susan Ford
Chief Executive Officer
Michiana Hematology Oncology
South Bend, Ind.

Douglas Flora, MD, LSSBB
Executive Medical Director, Oncology Services
St. Elizabeth Healthcare
Edgewood, Ky.

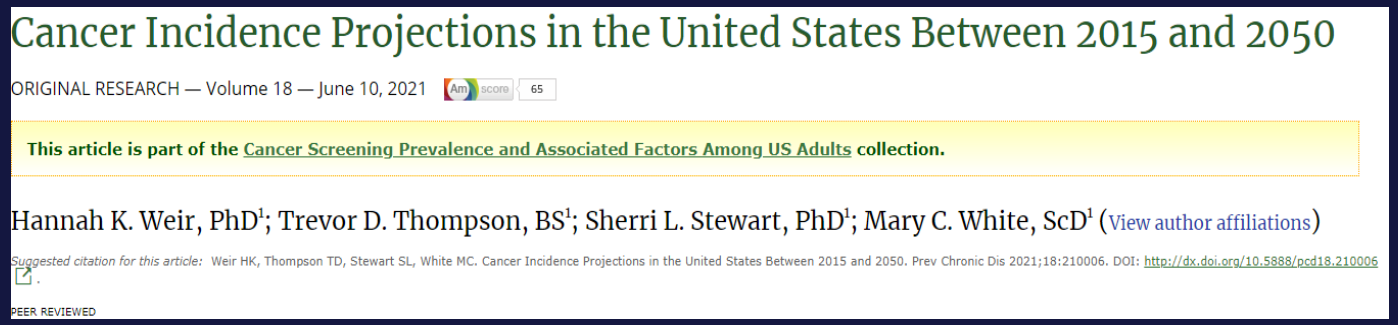
Matt Devino, MPH
Director, Cancer Care Delivery and Health Policy
Association of Community Cancer Centers
Rockville, M.D.

BACKGROUND

Basic Facts:

- 16.9 million Americans with a history of cancer were alive on January 1, 2019, expected increase to 22.1 million by 2030[2]
- About 1.9 million new cancer cases expected in 2022[4] growth rate is increasing!
- Increased number of survivors has profound implications for healthcare and cancer surveillance resource needs in the United States, including the need for oncology specialists and certified tumor registrars

3



Cancer Incidence Projections in the United States Between 2015 and 2050

ORIGINAL RESEARCH — Volume 18 — June 10, 2021 Am score 65

This article is part of the Cancer Screening Prevalence and Associated Factors Among US Adults collection.

Hannah K. Weir, PhD[1]; Trevor D. Thompson, BS[1]; Sherri L. Stewart, PhD[1]; Mary C. White, ScD[1] (View author affiliations)

Suggested citation for this article: Weir HK, Thompson TD, Stewart SL, White MC. Cancer Incidence Projections in the United States Between 2015 and 2050. Prev Chronic Dis 2021;18:210006. DOI: http://dx.doi.org/10.5888/pcd18.210006.

PEER REVIEWED

5

J Oncol Pract. 2014 Jan;10(1):39-45. doi: 10.1200/JOP.2013.001319.

Projected supply of and demand for oncologists and radiation oncologists through 2025: an aging, better-insured population will result in shortage

Wenya Yang [1], James H Williams, Paul F Hogan, Suanna S Bruinooge, Gladys I Rodriguez, Michael P Kosty, Dean F Bajorin, Amy Hanley, Ashley Muchow, Naya McMillan, Michael Goldstein

NORTHWEST MEDICAL SPECIALTIES, LLC (NWMS)

Jvion (Artificial Intelligence[AI])

- Technology platform that helps identify high-risk patients in order for a practice to allocate staffing resources appropriately to improve outcomes
- The tool has multiple "vectors," but NWMS focused mostly on readmissions and 30-day mortality
- NWMS assigned a non-clinical patient care coordinator to screen the Jvion dashboard for high-risk patients and coordinate care according to our internal protocols for specific visit types: acute care visits, supportive care visits, social work visits
- Had to make the difficult decision to stop using this tool when the OCM ended due to cost even though we know the value of the product

MICHIANA HEMATOLOGY ONCOLOGY

Unburdening Revenue Cycle Teams Through Technology & Data
AC3 Health

Automated workflows and meaningful, actionable data analytics

- Synergized internal and external data into one environment for easy digestion
- Automated fee schedule updates
- Mapping of all payers to accurate fee schedules
- 100% transaction level claims auditing against contractual fee schedule
- Claims prioritization intelligence
- Underpayment recovery service
- Practice and operational performance analytics

INNOVATION THAT BENEFITS PATIENTS & PROVIDERS

MEDTECH

FDA clears Paige's AI as first program to spot prostate cancer in tissue slides

By **Conor Hale** • Sep 22, 2021 11:59am

JAMA Guide to Statistics and Methods

Using Free-Response Receiver Operating Characteristic Curves to Assess the Accuracy of Machine Diagnosis of Cancer

Chaya S. Moskowitz, PhD

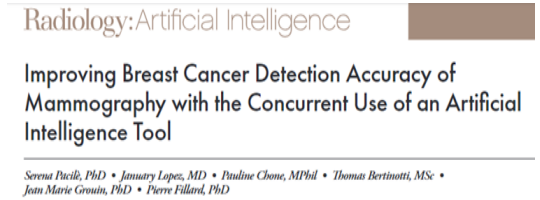
NEJM Evidence

Published March 28, 2022
NEJM Evid 2022; 1 (5)
DOI: 10.1056/EVIDoa2100058

ORIGINAL ARTICLE

AI Estimation of Gestational Age from Blind Ultrasound Sweeps in Low-Resource Settings

Teeranan Pokaprakarn, Ph.D.,[1] Juan C. Prieto, Ph.D.,[2] Joan T. Price, M.D., M.P.H.,[3,4] Margaret P. Kasaro, M.D., M.P.H.,[3,5] Ntazana Sindano, B.Sc.,[3] Hina R. Shah, M.S.,[2] Marc Peterson, M.S.,[4] Mutinta M. Akapelwa, B.Sc.,[3] Filson M. Kapilya, B.Sc.,[3] Yuri V. Sebastião, Ph.D.,[4] William Goodnight III, M.D., M.S.,[4] Elizabeth M. Stringer, M.D., M.Sc.,[4] Bethany L. Freeman, M.P.H., M.S.W.,[4] Lina M. Montoya, Ph.D.,[1] Benjamin H. Chi, M.D., M.Sc.,[3,4] Dwight J. Rouse, M.D., M.S.P.H.,[6] Stephen R. Cole, Ph.D.,[7] Bellington Vwalika, M.D., M.Sc.,[4,5] Michael R. Kosorok, Ph.D.,[1] and Jeffrey S. A. Stringer, M.D.[3,4]



Radiology: Artificial Intelligence

Improving Breast Cancer Detection Accuracy of Mammography with the Concurrent Use of an Artificial Intelligence Tool

Serena Pacilè, PhD • January Lopez, MD • Pauline Chone, MPhil • Thomas Bertinotti, MSc • Jean Marie Grouin, PhD • Pierre Fillard, PhD

Research

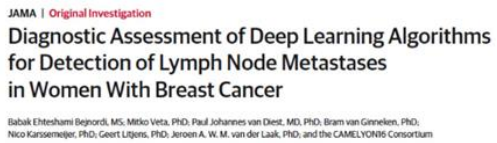
JAMA | Original Investigation | INNOVATIONS IN HEALTH CARE DELIVERY

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

EDITORIAL

Deep Learning Algorithms for Detection of Lymph Node Metastases From Breast Cancer
Helping Artificial Intelligence Be Seen

Jeffrey Alan Golden, MD



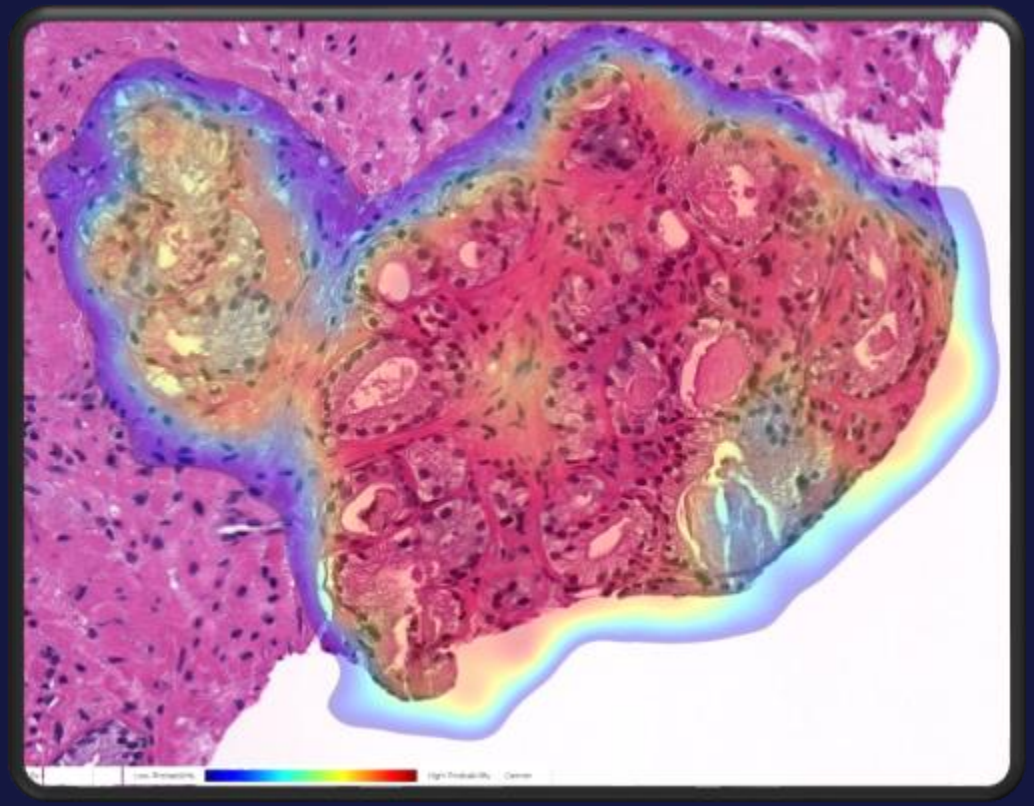
JAMA | Original Investigation

Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer

Babak Ehteshami Bejnordi, MS; Mitko Veta, PhD; Paul Johannes van Diest, MD, PhD; Bram van Ginneken, PhD; Nico Karssemeijer, PhD; Geert Litjens, PhD; Jeroen A. W. M. van der Laak, PhD; and the CAMELYON16 Consortium

AI DETECTING PROSTATE CANCER NEAR PERFECTION

- Images from more than 1 million parts of stained tissue slides from patient biopsies used to teach AI to discriminate between healthy and abnormal tissue
- Tested on 1,600 slides from 100 patients
- AI demonstrated 98% sensitivity and 97% specificity at detecting prostate cancer
- AI also flagged 6 slides not noted by expert pathologists



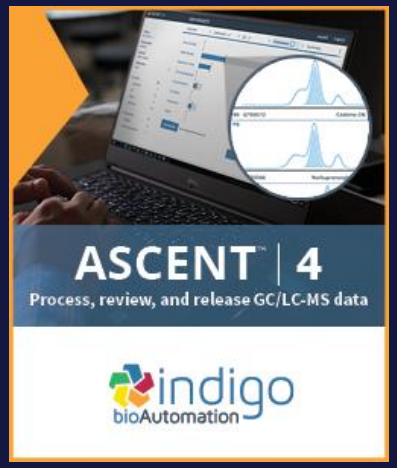
ST. ELIZABETH CANCER CARE

Capacity Management

- AI-powered patient flow optimization, such as real-time location systems, ensures patients move through a facility with the right level of care as efficiently as possible.
- AI-optimized schedule management gives clinicians more time with their patients
- AI-decision-support algorithms improve the ability of front-line doctors and caregivers to make more accurate diagnoses and provide better treatment.
- Immediate gains in reducing clinical errors

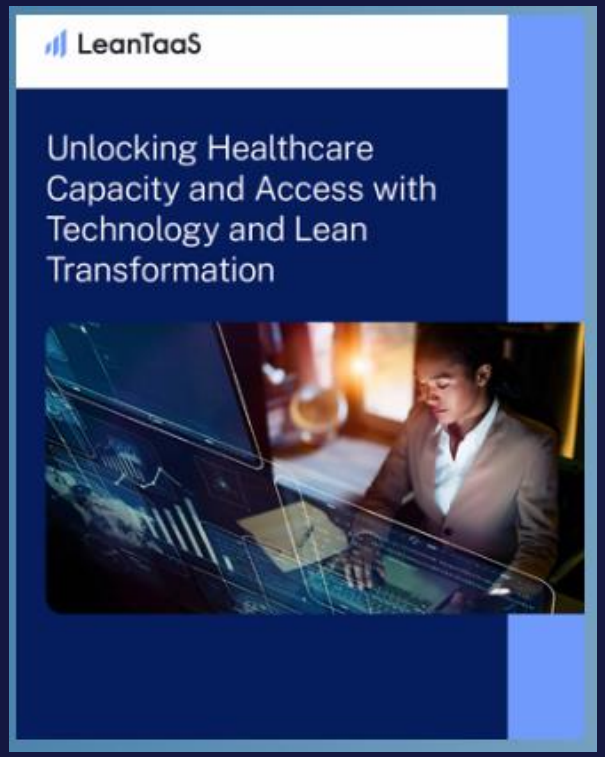
EFFICIENCIES FOR SYSTEMS AND PROVIDERS

15



How Novant Health Optimized OR Capacity to Restore Elective Surgery & Achieve Stronger Financial Health

16,17



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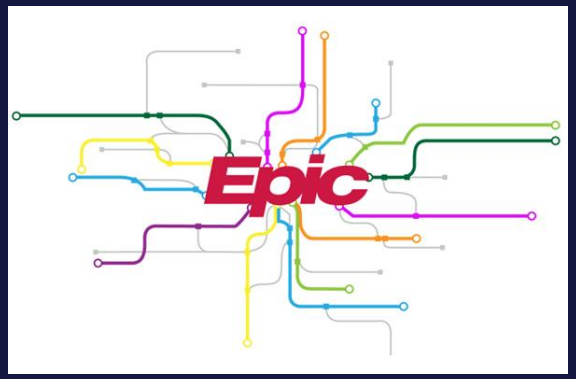

19,20

21

HOPES FOR AI TO MAKE HEALTHCARE HUMAN AGAIN[22]

"I think we can all agree there isn't any algorithm for empathy. This is what we are for—the human connection. We aren't suddenly going to become more intelligent. But machines are. Our charge is to get more humane."

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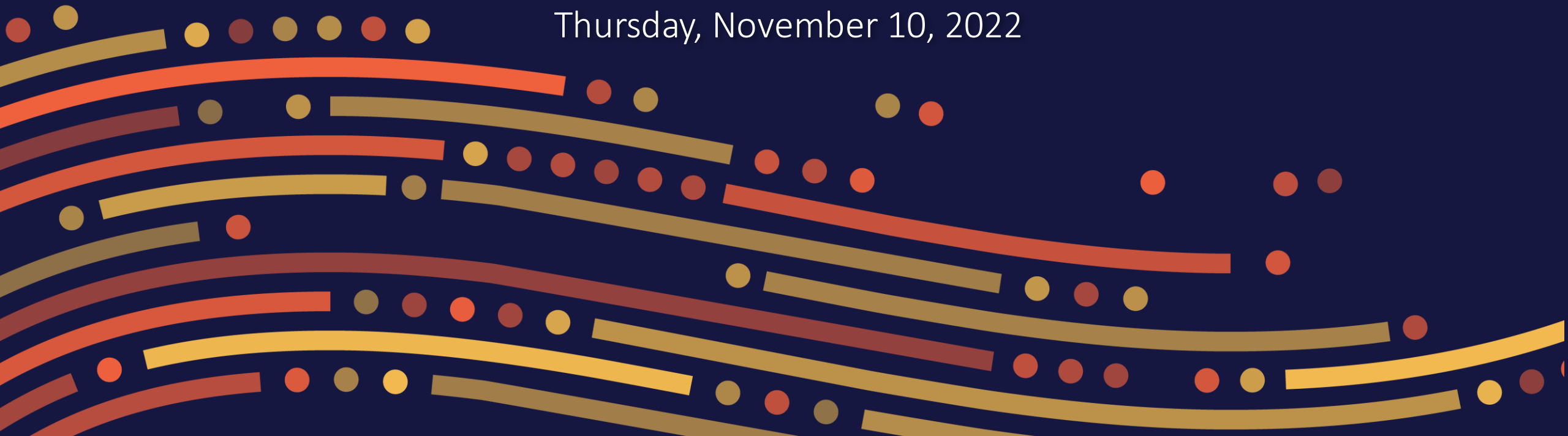
ASSOCIATION OF COMMUNITY CANCER CENTERS (ACCC)

ACCC 2022-2023 President's Theme Tech Talk #3

Applying a Health Equity Lens to Implementing Remote Patient Monitoring

Thursday, November 10, 2022

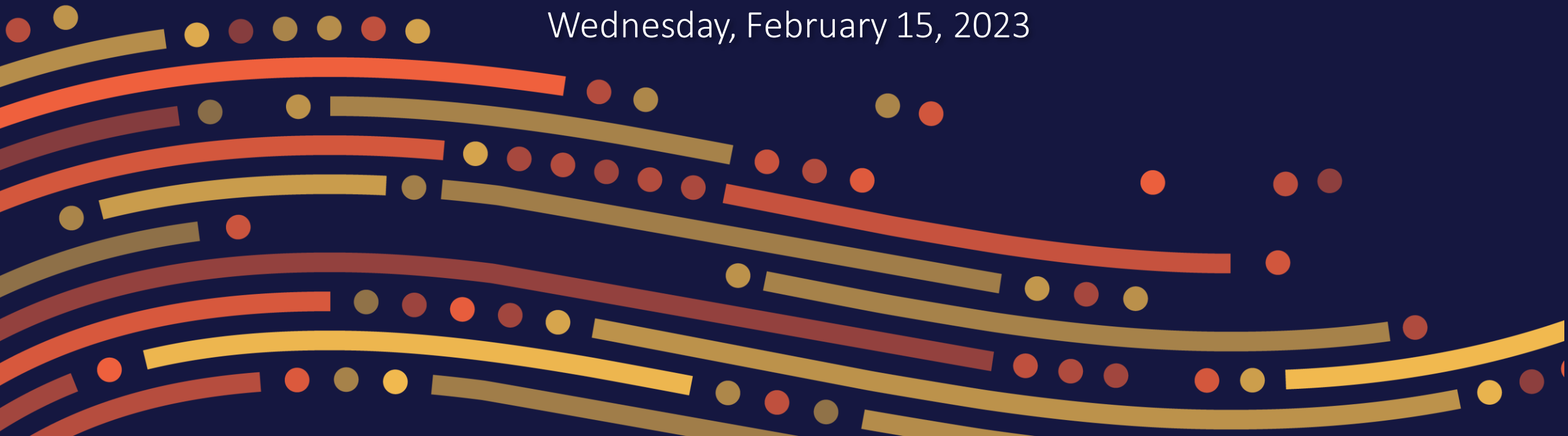


ASSOCIATION OF COMMUNITY CANCER CENTERS (ACCC)

ACCC 2022-2023 President's Theme Tech Talk #4

The Impact of Big Data and Artificial Intelligence on Oncology

Wednesday, February 15, 2023



TECH TALK SPEAKERS

Rick Baehner, MD
Chief Medical Officer, Precision Oncology
Exact Sciences
Redwood City, Calif.

Blythe Adamson, PhD, MPH
Principal Scientist
Flatiron Health
New York, N.Y.

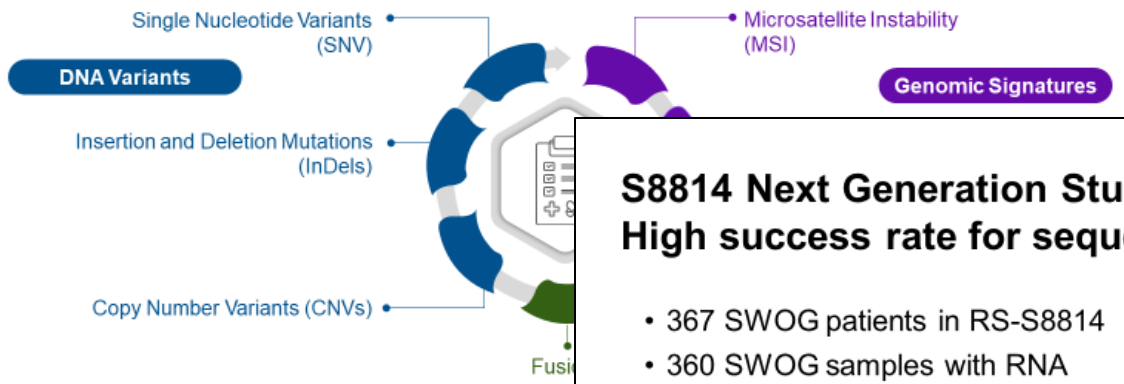
Sarah McGough, PhD
Senior Data Scientist
Genentech
San Francisco, Calif.

John Frownfelter, MD, FACP
Lead, Data Driven Healthcare
NTTData
Highland, Mich.

2-4

Components of a CGP Test

To discover all biomarkers included in clinical practice guidelines and key biomarkers in clinical trials, a CGP test should assess:



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5

S8814 Next Generation Study Sequencing
High success rate for sequencing S8814 samples

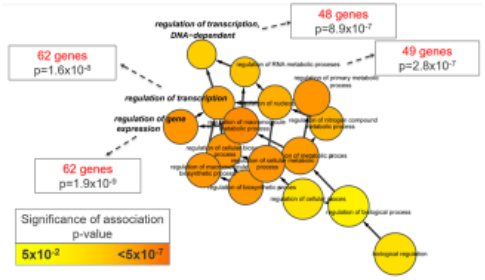
- 367 SWOG patients in RS-S8814
- 360 SWOG samples with RNA (≥100 ng)
- 354 patient sample sequenced in final data set
- 86,999,247,640 total reads
- ~4.72 trillion total base pairs

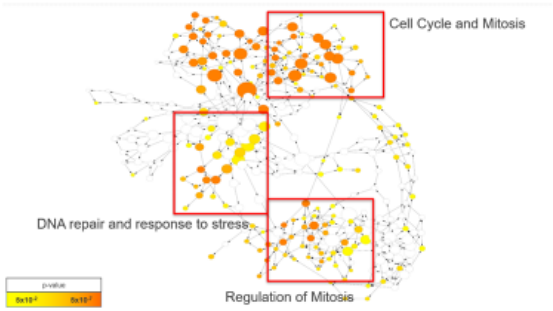
Albain K. SABCS 2014

5

Tamoxifen Arm: prognosis

- Good Biology: Genes associated with better outcomes highlight regulation of transcription
- Bad Biology: Genes associated with worse outcomes highlight proliferation & mitosis markers





Albain K. SABCS 2014

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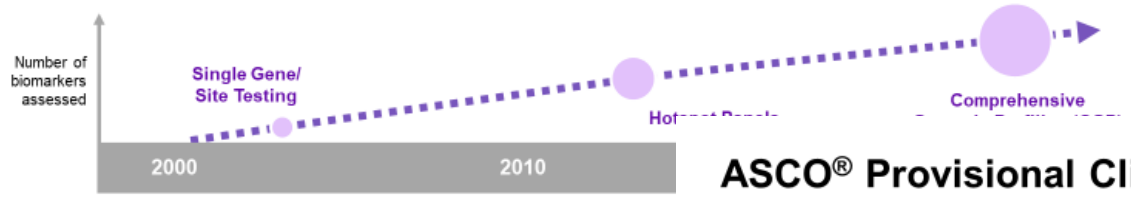
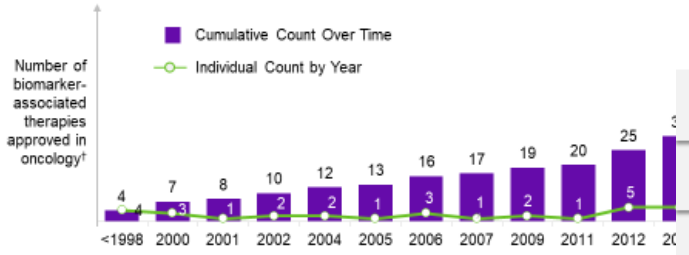
6-8

Comprehensive Genomic Profiling (CGP)





†Number of US Oncology medicines with required or recommended predictive biomarker testing.

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9

ASCO® Provisional Clinical Opinion for Somatic Testing in Patients with Metastatic or Advanced Cancer

- Biomarker testing recommended if cancer type has ≥1 approved biomarkers to guide therapy
  - Pan-tumor indications provide rationale for genomic testing for all solid tumors
- Multigene panel-based assays preferred if cancer type has ≥2 approved biomarkers
- dMMR/MSI and TMB testing recommended if pa
- Fusion and exon-skipping variant testing recom
  - If cancer type has approved fusion-targeted c
  - If other targetable alterations have not been f
- For detecting expressed fusions, RNA-based ap

EXACT SCIENCES

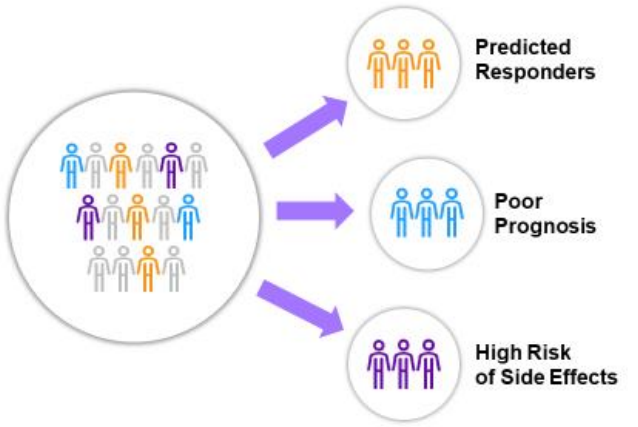
1. Chakravarty D, et al. JCO. 2022;40(11):1231-1258.

Biomarkers in Cancer

Molecular characteristics measured as an indicator of risk of cancer, occurrence of cancer, or patient outcome[1]

Clinical Applications:

- Cancer risk assessment
- Screening and early detection
- Accurate diagnosis
- Patient prognosis
- Prediction of response to therapy
- Surveillance and monitoring response

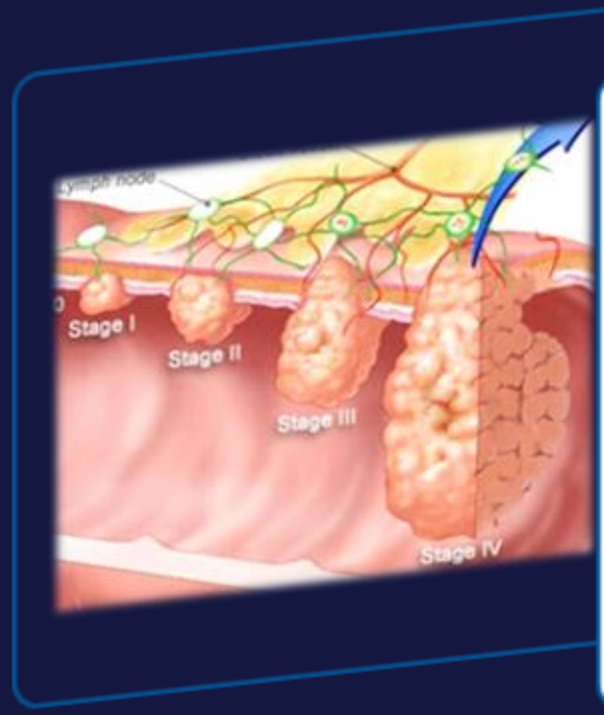


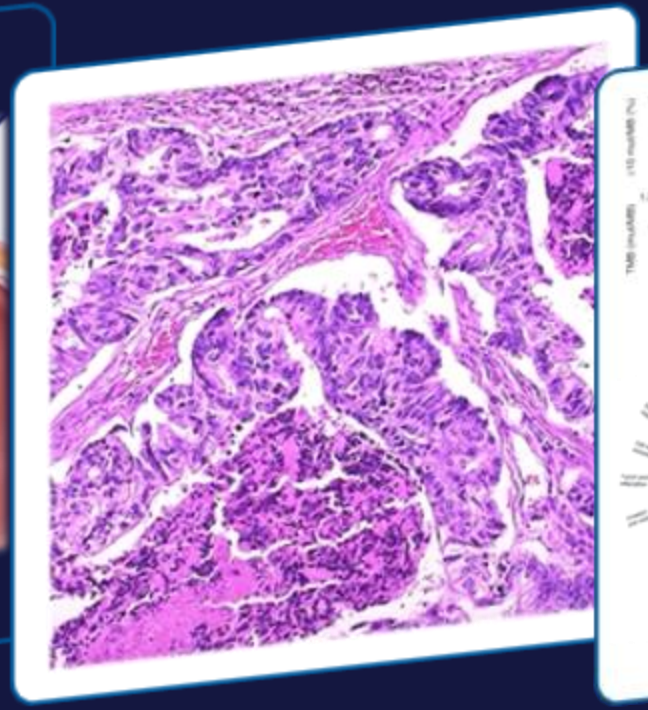
1. Sarhadi VK and Armengol M. Biomolecules. 2022;12:1021
2. Pritchard D, et al. JCO Precis Oncol. 2022;6:e2100349

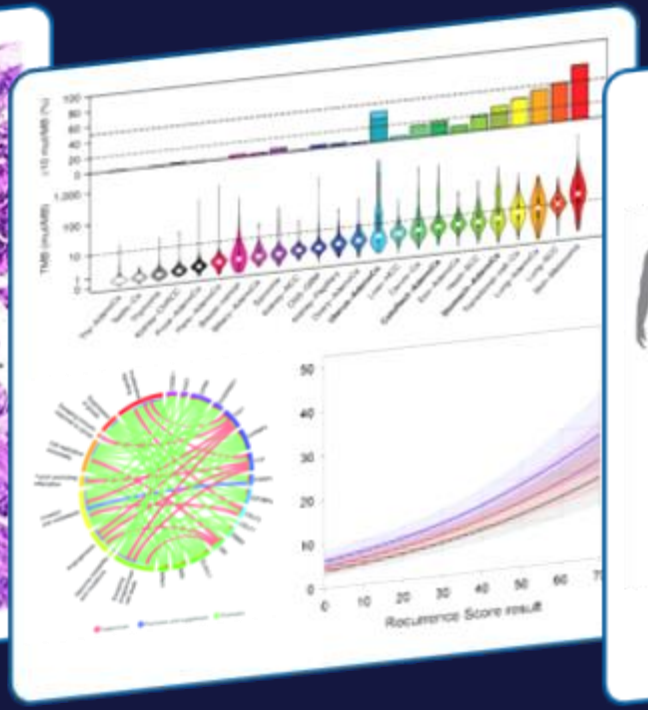
6

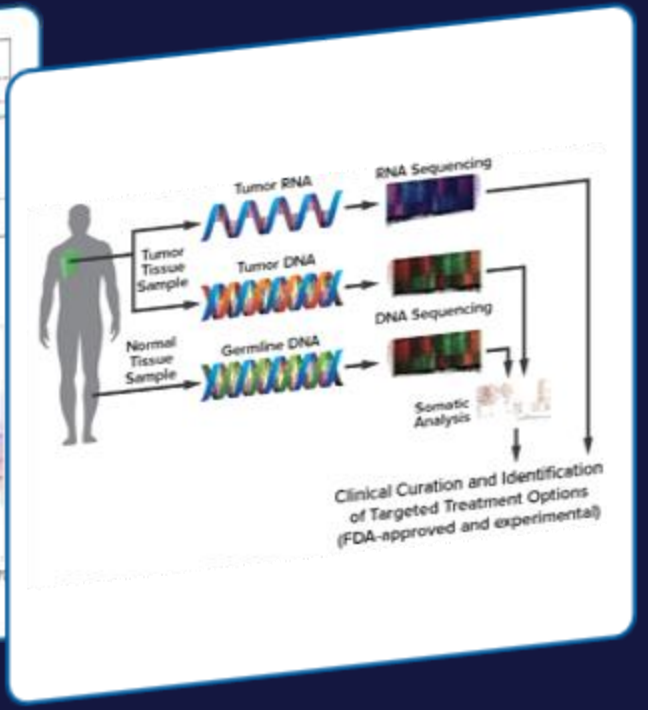
10-11

Value of Multiomics: Addition of Orthogonal Prognostic and/or Predictive Information to Baseline ctDNA Results









Clinico-pathologic factors
- Number of nodes examined
- T-Stage
- Number of positive nodes

H&E analysis
- Artificial intelligence/machine learning
- Prognostic/predictive signatures

Tissue derived genomic data
- Transcriptomic signatures, tumor microenvironment
- TMB, MSI, TCR, HLA LOH, neoantigens
- Minimal residual disease

Germline toxicity variants
- Dihydropyrimidine dehydrogenase (DPYD)
- Thymidylate synthase (TYMS)

TMB = tumor mutation burden; MSI = microsatellite instability; TCR = T-cell receptor; HLA LOH = human leukocyte antigen loss of heterozygosity

Introducing Digital Human

Digital Human:

- Is lifelike animated avatar
- Can be customized exterior and interior
- Can recognize real-time situations
- Can react them like human

Type of Digital Human

	Interactive	Not Interactive
Non-Existing Character	Auto Reception/ Auto Kiosk/ Digital Assistant	Virtual Model/ Influencer
Existing Character	Digital Clone of Specialist	Video Guide for Museum

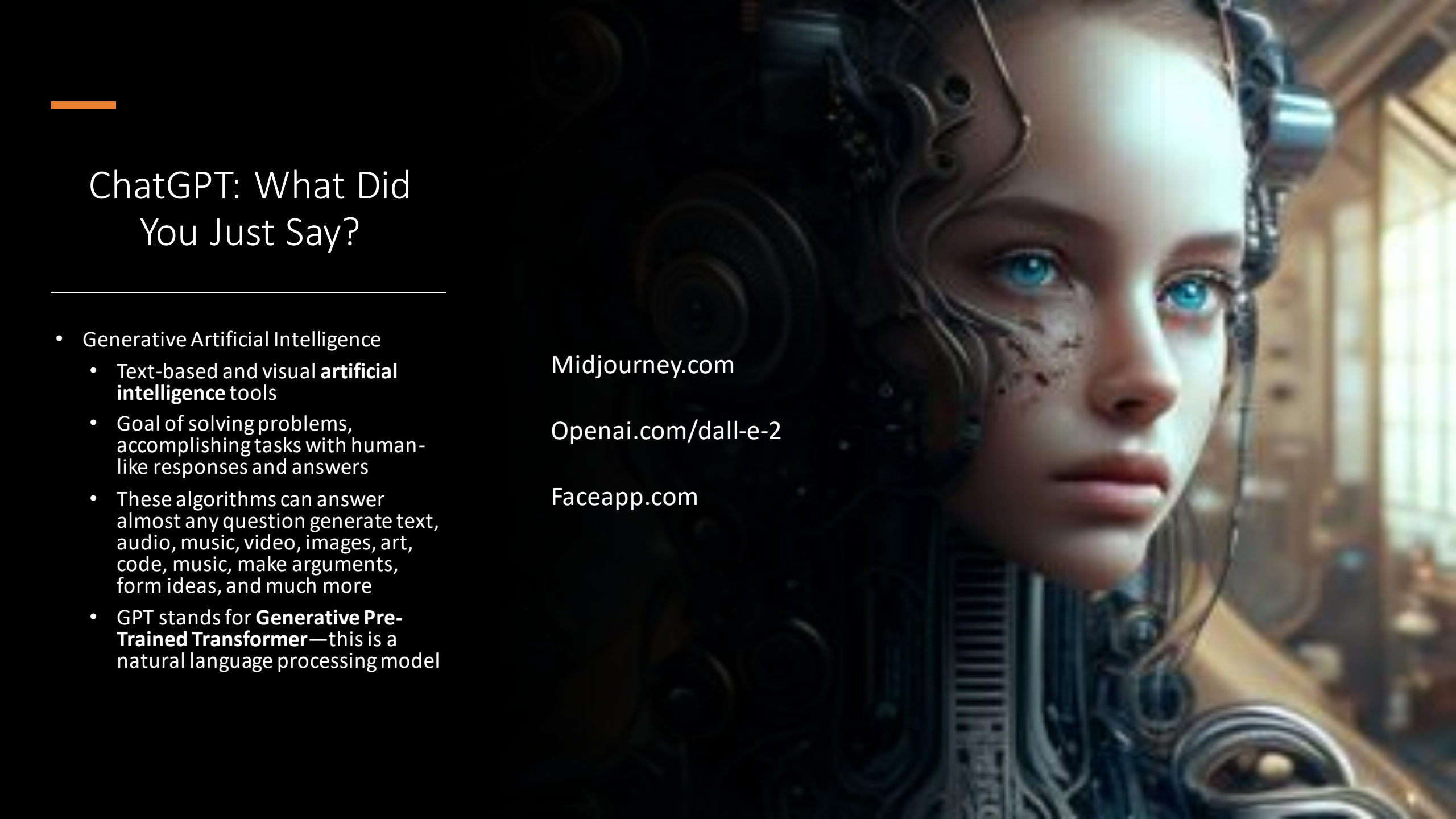
ChatGPT: What Did You Just Say?

- Generative Artificial Intelligence
  - Text-based and visual **artificial intelligence** tools
  - Goal of solving problems, accomplishing tasks with human-like responses and answers
  - These algorithms can answer almost any question generate text, audio, music, video, images, art, code, music, make arguments, form ideas, and much more
  - GPT stands for **Generative Pre-Trained Transformer**—this is a natural language processing model

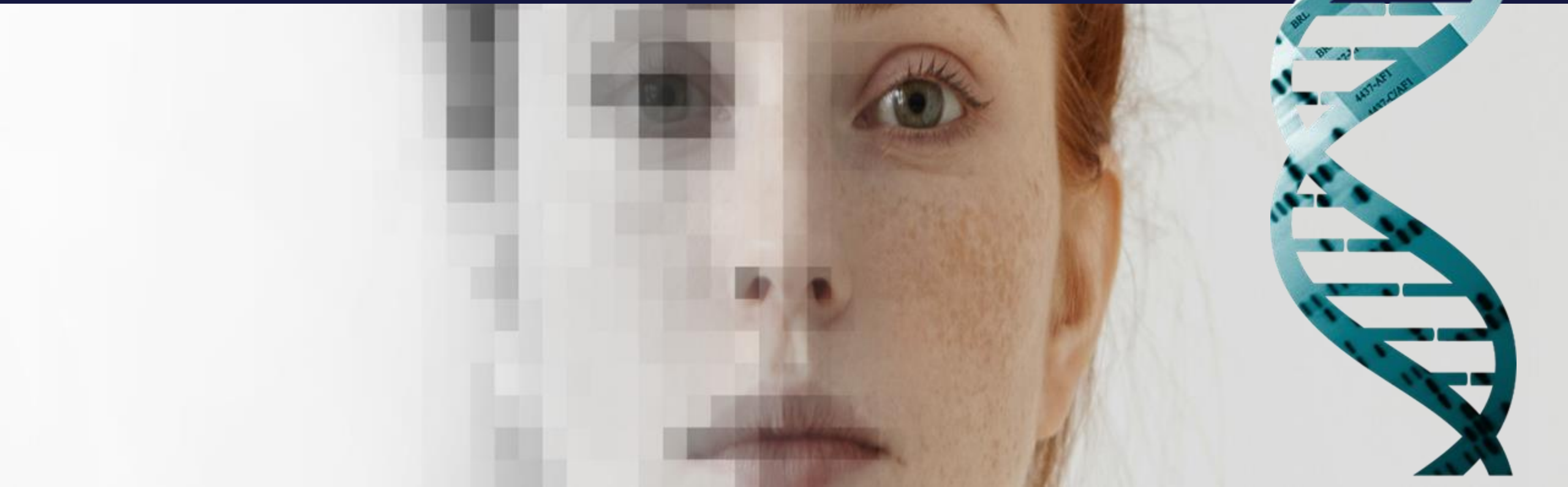
Midjourney.com

Openai.com/dall-e-2

Faceapp.com

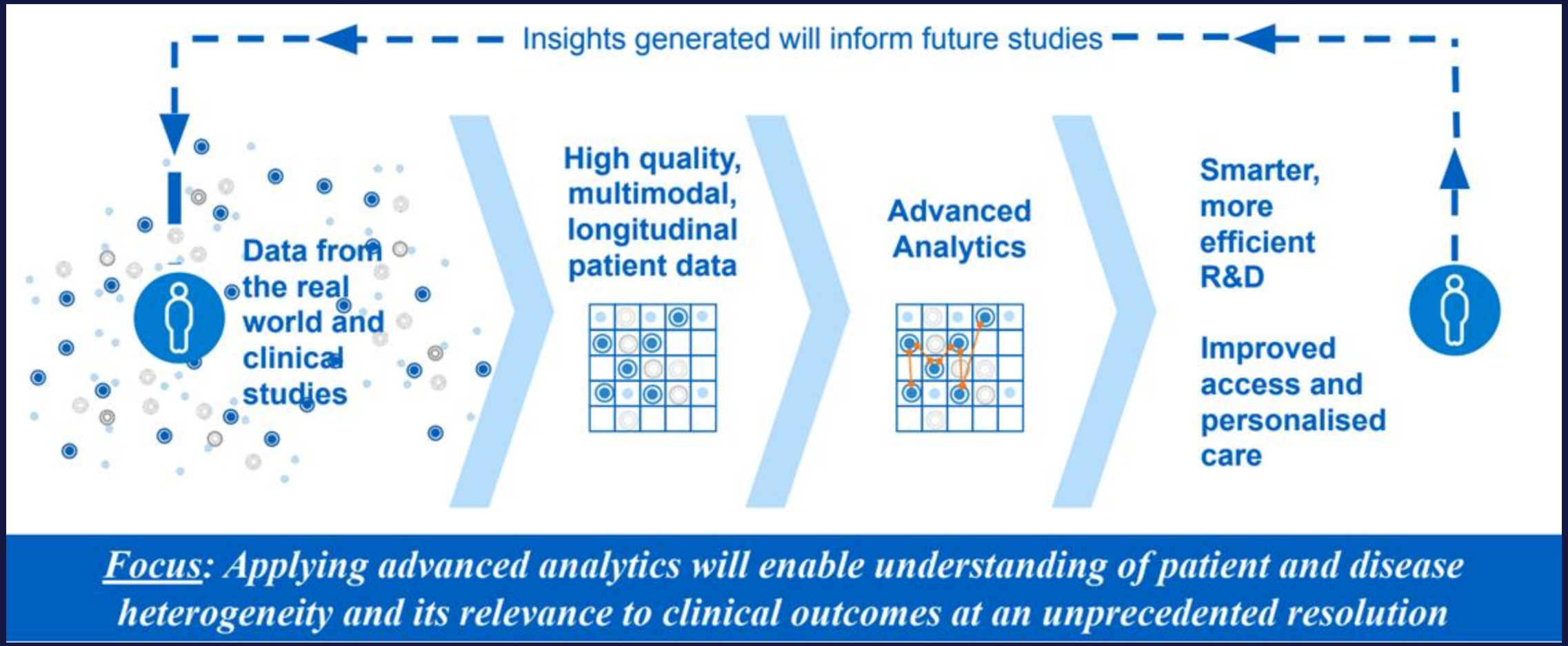


Oncology Insights in Drug Development: Machine Learning from an Industry Perspective



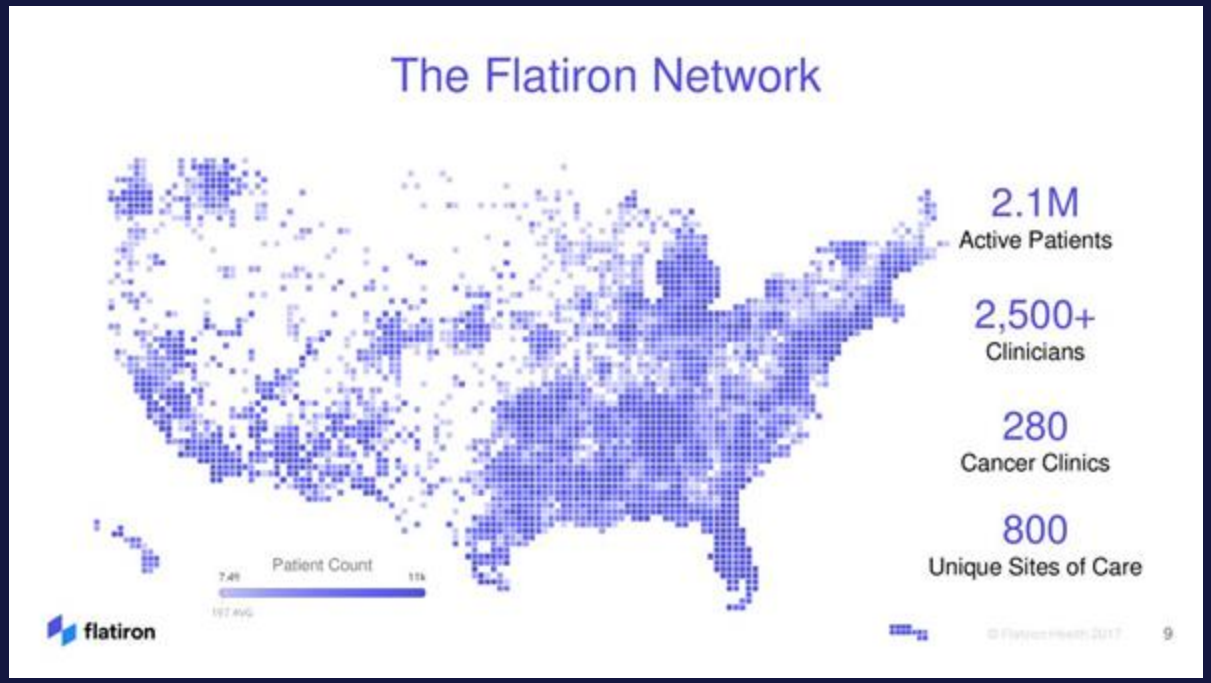
Oncology Insights in Drug Development: Machine Learning from an Industry Perspective

At Genentech/Roche, data & advanced analytics are key enablers to transform healthcare

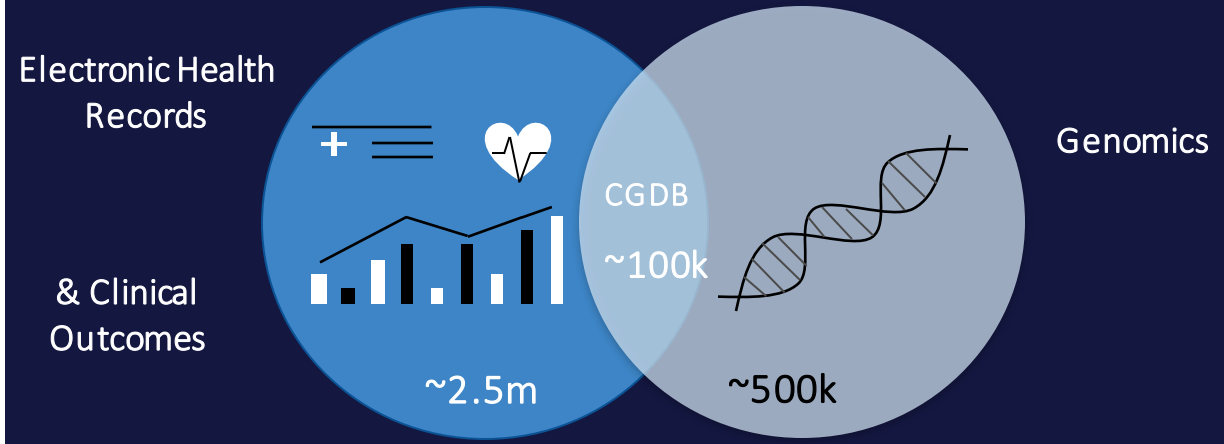


Oncology Insights in Drug Development: Machine Learning from an Industry Perspective

Real-word data enables us to capture a larger & broader population of patients with cancer



Flatiron-Foundation Medicine Clinico-Genomic Database (CGDB)



Spotlight on:
Disease & Patient Insights

Cultivating tumor-agnostic insights in light of the evolving paradigm of anti-cancer treatment

12

PRECISION ONCOLOGY NEWS

Business & Policy | Biomarkers | Cancer Specialties | Oncology Trends | Resources

Home » Disease Areas » Cancer

Industry Interest in Pan-Cancer Indications Growing With FDA Support Despite Challenges

May 29, 2019 | Turna Ray

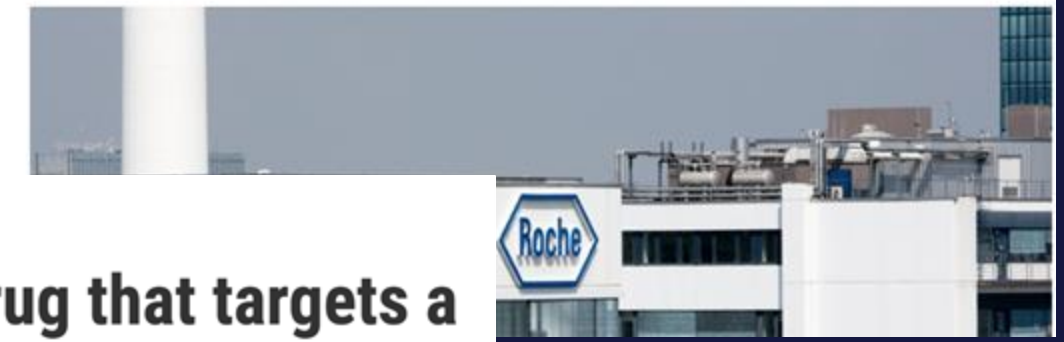
13

BIOPHARMADIVE Deep Dive Library Events Topics

Roche cancer drug the 3rd approved for pan-tumor use

Published Aug. 15, 2019 • Updated Aug. 15 2019, 3:15 p.m. PDT

Ned Pagliarulo
Lead Editor



FDA NEWS RELEASE

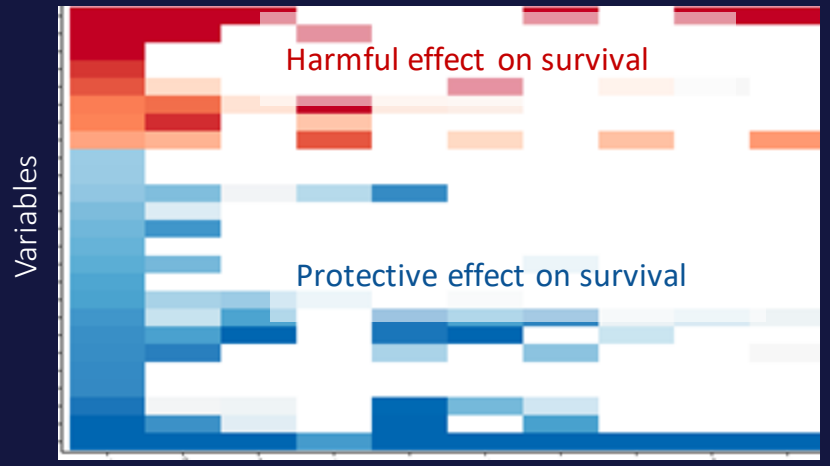
FDA approves third oncology drug that targets a key genetic driver of cancer, rather than a specific type of tumor

14

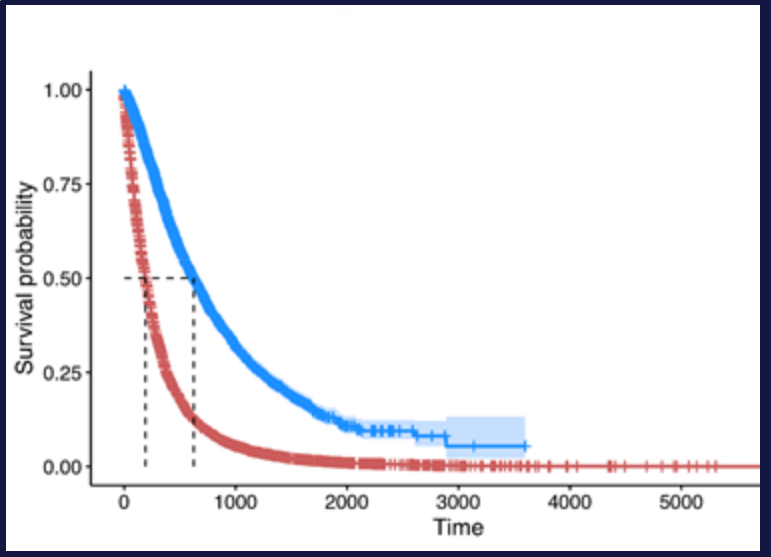
Spotlight on:
Disease & Patient Insights

Using machine learning to autonomously identify the most important tumor-agnostic clinical and genomic predictors of survival

Train survival machine learning models on ***thousands of clinical-genomic variables*** across ***dozens of cancer types***



Identify ***key predictors*** of survival across cancers



Better predicting *high-* and *low-risk* patients can enable prognostic enrichment and treatment strategy

Spotlight on:
Clinical Trial Design

How can we create broader and more inclusive clinical trials without compromising estimates of treatment effects?

Clinical Trials

Real World

Machine Learning Models Can Be Trained to Abstract Like Experts

Abstracted Datatable Example

Patient	ROS1_Status	ROS1_Test_Date
ID_001	Positive	15 Jan 2020
ID_023	Negative	01 Sep 2014
ID_079	Negative	05 Jul 2018
…	…	…
ID_450	Negative	30 Apr 2021
ID_503	Positive	06 Dec 2015

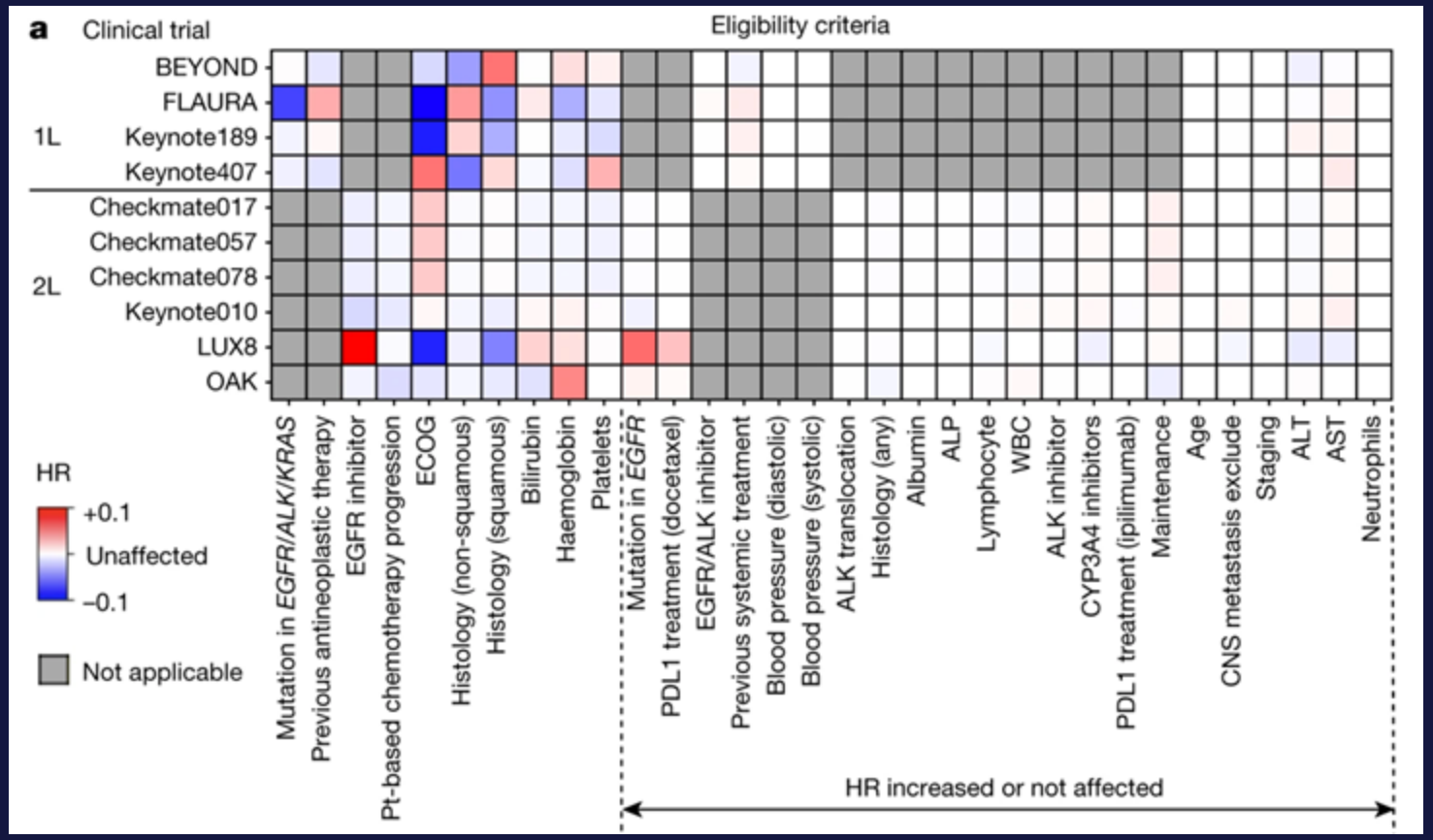
ML-extracted Datatable Example

Patient	ROS1_Status	ROS1_Test_Date
ID_001	Positive	15 Jan 2020
ID_023	Positive	01 Sep 2014
ID_088	Negative	05 Jul 2018
…	…	…
ID_456	Positive	15 Oct 2020
ID_502	Negative	06 Dec 2015

ML models are trained to extract the same data elements as expert abstractors and align with the same data model

Spotlight on: Clinical Trial Design[15]

Training predictive models to optimize data-driven set of eligibility criteria



Data-driven criteria enlarges pool of eligible patients by **107%** on average, without compromising treatment effect.

Relaxing thresholds for key labs like **bilirubin**, **hemoglobin**, **platelets**, and **ALP** yields no impact on trial conclusions, while making trials **more inclusive**.

The Horizon: What's Next for Big Data & Machine Learning in Industry?

- Scaling insights
- Operationalizing tools—embedding data-driven analytics in clinical practice
- Weighing ethics and risk to patient **interpretation, fair models**

Forbes AI 50 2023
$27B funding!

This is what it looks like to work in health tech, sitting beside some of the most brilliant artificial intelligence engineers in the world

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TO LEARN MORE ABOUT THE 2022-2023 ACCC PRESIDENT'S THEME

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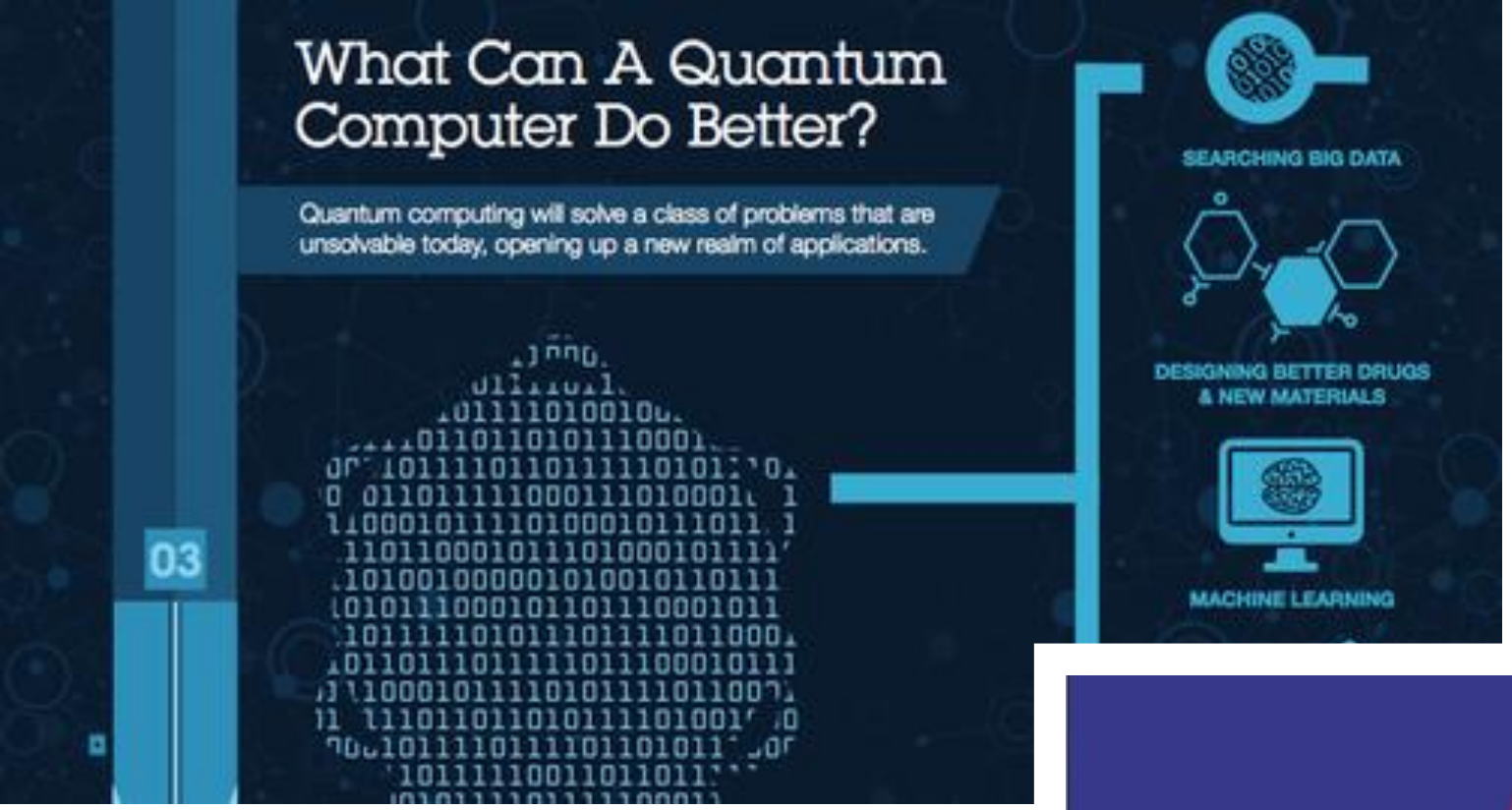
Association of Community Cancer Centers


What Can A Quantum Computer Do Better?
Quantum computing will solve a class of problems that are unsolvable today, opening up a new realm of applications.
03
SEARCHING BIG DATA
DESIGNING BETTER DRUGS & NEW MATERIALS
MACHINE LEARNING


Illumina
bioinformatics
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genetics
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Illumina wants to sequence your whole genome for $100
Posted Jan 10, 2017 by Sarah Buhr (@sarahbuhr)
Next Story
The first sequencing of the whole human genome in 2003 cost roughly $2.7 billion, but DNA sequencing giant Illumina has now unveiled a new machine that the company says is "expected one day" to order up your whole genome for less than $100.
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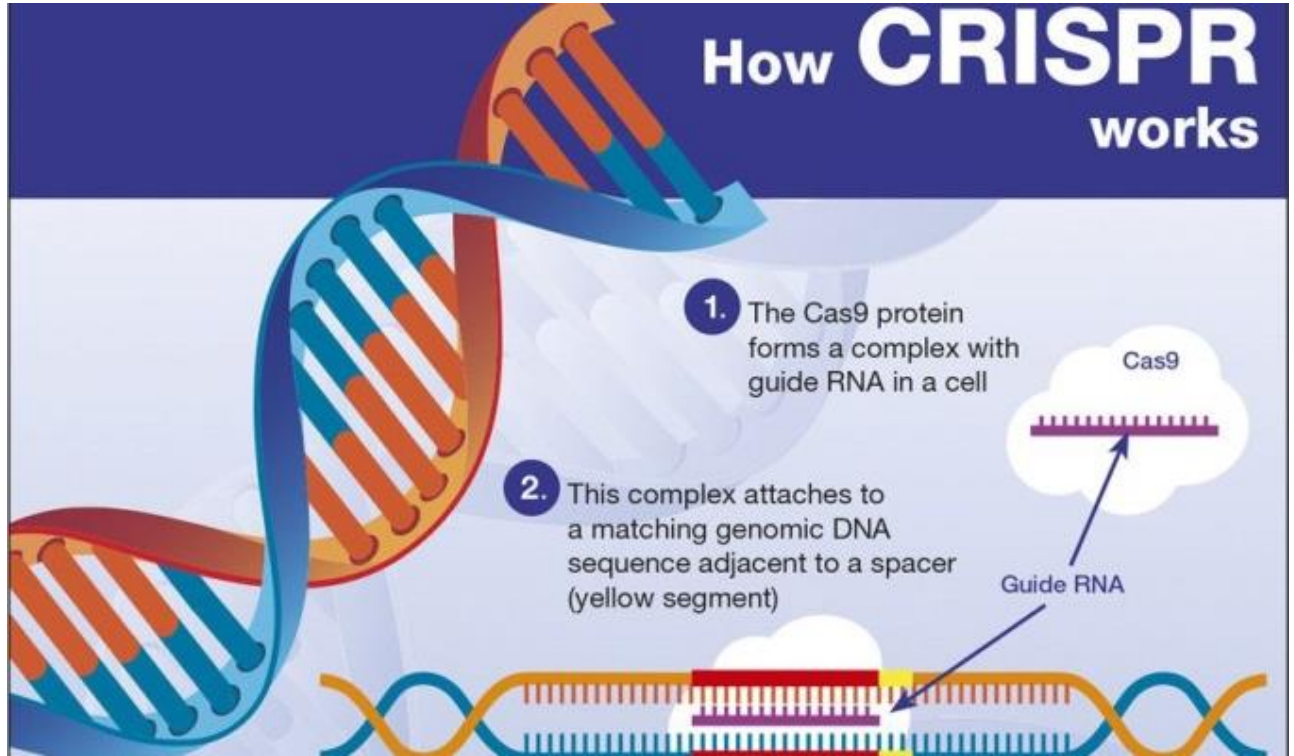
OVERVIEW
At Illumina, their goal is to apply innovative technologies and revolutionary assays to the analysis of genetic variation and function, making studies


How CRISPR works
1. The Cas9 protein forms a complex with guide RNA in a cell
Cas9
2. This complex attaches to a matching genomic DNA sequence adjacent to a spacer (yellow segment)
Guide RNA

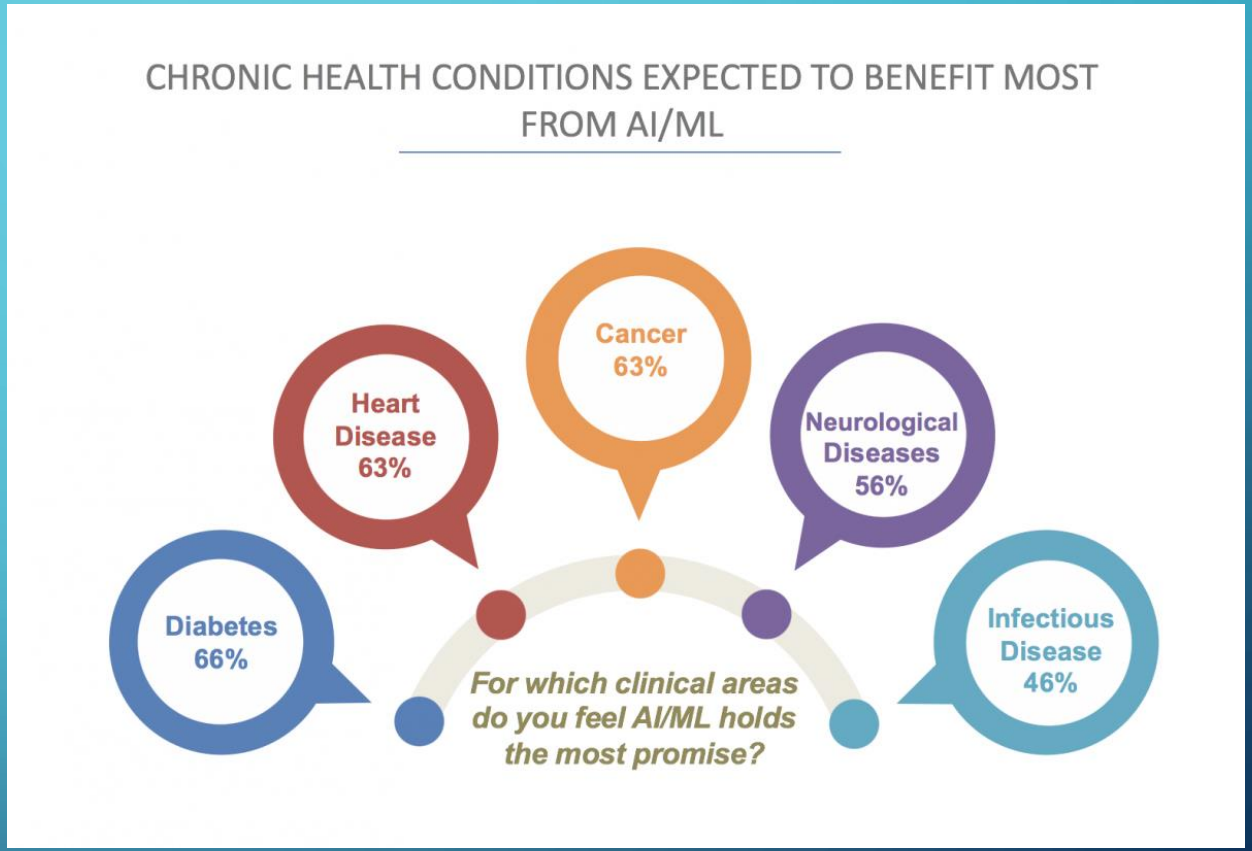
In 2012, scientists at the University of Leicester decided to print out a complete version of the human genome. When they were done, they had a 130-volume monument to humanity's essence—a seemingly endless sequence of As, Ts, Cs, and Gs in four-point type. Curiously, the printing project's costs already exceeded the costs of actually sequencing the genome anew. Since then, the price differential has only grown. Cas Kramer (Univ. Leicester) »

PUBLIC

PRIVATE

INFORMATION TSUNAMI

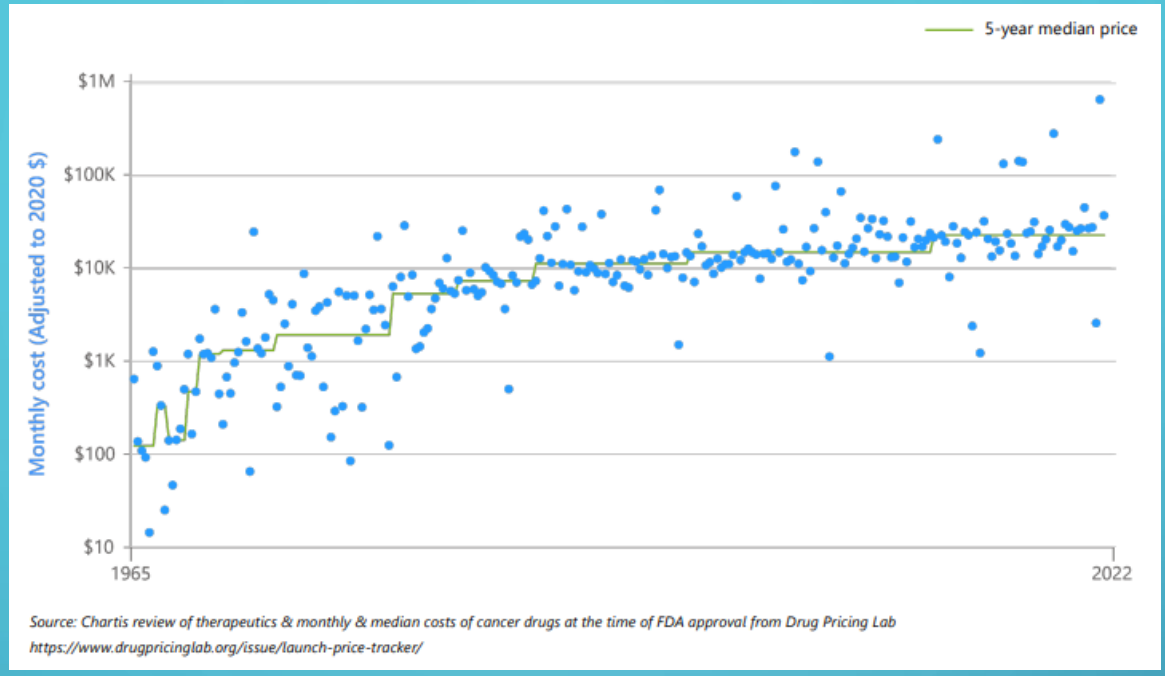
Data curation and retrieval, not retention



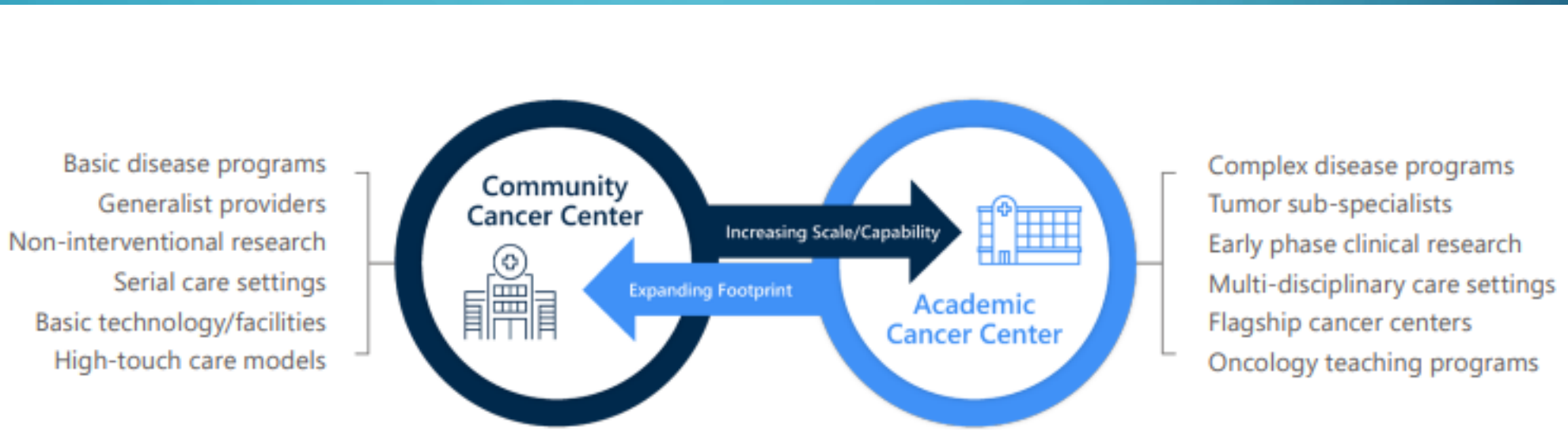
THE PROMISE OF AI & ML IN HEALTHCARE

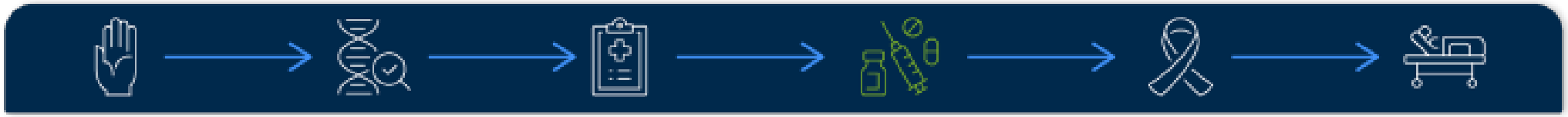
	FUTURE FORCE IN ONCOLOGY	WHAT CANCER CENTERS NEED TO DO
1	**Prevention and treatment advances will redefine the cancer "consumer"**	Excel in the spaces before and after cancer, addressing the needs of millions of cancer "pre-vivors" and survivors.
2	**Rapid innovation will remake the requirements of contemporary care**	Build care models that reflect the complexity of the disease, capable of adapting to high-velocity clinical innovation.
3	**Unsustainable costs will prompt intervention across the value chain**	Diversify the business model and create value-based competence, preparing for challenges to today's onco-economics.
4	**Traditional provider identities will blur, creating new ecosystems of care**	Redefine target patient segments and the role of partnerships in a marketplace of fungible community and academic roles.
5	**New entrants will accelerate disruption and innovation in the care continuum**	Assemble the expertise and capabilities required to modernize the experience of cancer care.

	NOW	NEXT	
 **DIAGNOSTIC/ SURGERY**	• MR, PET, CT • Procedural biopsy • Next-gen sequencing • Robotic surgery (DaVinci)	• Nano-tech imaging • Photoacoustic tomography • Liquid biopsy (cfDNA)	• Full "omics" panel • AI smart robotics • Intra-op navigation
 **IMMUNO- THERAPY**	• Checkpoint inhibitors (PD-L1) • Autologous ACT (CAR-T) • Bispecific antibodies • Cell/viral vaccines	• Next-gen ICIs (TIGIT, LAG-3) • Off-the-shelf ACT (CAR-T, TIL, NIK) • Multi-specific antibodies	• Polypeptide conjugates • RNA-based vaccines (mRNA, siRNA, miRNA)
 **TARGETED THERAPY**	• Fecal transfer • TKIs (RET, MET, EGFR) • Antibody drug conjugates • Proteasome inhibitors (PARP)	• Engineered bacteria • Intratumoral microbiomics • Gene editing (CRISPR)	• Combination TKIs • Nanoparticle delivery • Immune + PARP
 **RADIATION THERAPY**	• Adaptive therapy (MRLinAc) • Pencil-beam proton • Radiopharma (α / β) • Theranostics	• Radiation immune modulation • FLASH (Ultra high-doserate therapy) • Heavy particle (carbon ion)	• α -Immunotherapy, combination PARP/ICIs



Source: Chartis review of therapeutics & monthly & median costs of cancer drugs at the time of FDA approval from Drug Pricing Lab
https://www.drugpricinglab.org/issue/launch-price-tracker/





PREVENTION

Prevention
skinIO
Vincere Health

SDOH
Unite Us

SCREENING

Risk Screening
HALO Precision Diagnostics
Gabbi
Welwaze Medical

Hardware
iSono Health
NearWave

DIAGNOSIS

Education
Ankr
Outcomes4Me

Diagnositics
LIQUID BIOPSY
Adela
GRAIL

OMNICS ANALYSIS
Cancer IQ
Isabl

AI/IMAGING
Elephas
Sirona

TREATMENT

Navigation
Jasper
Navigating Cancer
OncoHealth
VieCure

Care Management
REPROSENT
vinehealth

Home Care
Canopy Health
Conversa Health
Karkinos Healthcare
Reimagine Care

SURVIVORSHIP

Survivorship
Belong.Life
Elly Health
Mend Together
VivorCare

Nutrition
Savor Health
ZEST Nutrition

EOL CARE

Palliative/ACP
Cake
Iris
Koda Health
Vital Decisions
VyncaCare

Hospice
Blue Monarch Hospice
Guaranteed Hospice

Decentralized Clinical Trials Aparito Medable ObvioHealth Science 37 Syneos Health

Risk-Enablement Platforms Azra AI Carevive Cohere Health Thyme Care Transcarent

Source: Inventory of digital enablement partially sourced from Flare Capital

AI POWERED MEDICAL LITERATURE ANALYSIS

Benefits of using AI for medical research:

Enhanced diagnostic capabilities

Accelerated drug discovery

Personalized medicine and treatment optimization

PERSONALIZED MEDICINE

Role of AI in enabling personalized treatment plans

Liquid biopsies (Nature article suggested one day screening for lung cancer could be as easy as taking a blood test – Lung-CLiP

- AI's cancer detection rate was comparable to the rate of radiologists, but systems are not designed to replace healthcare professionals

MEDICAL IMAGING

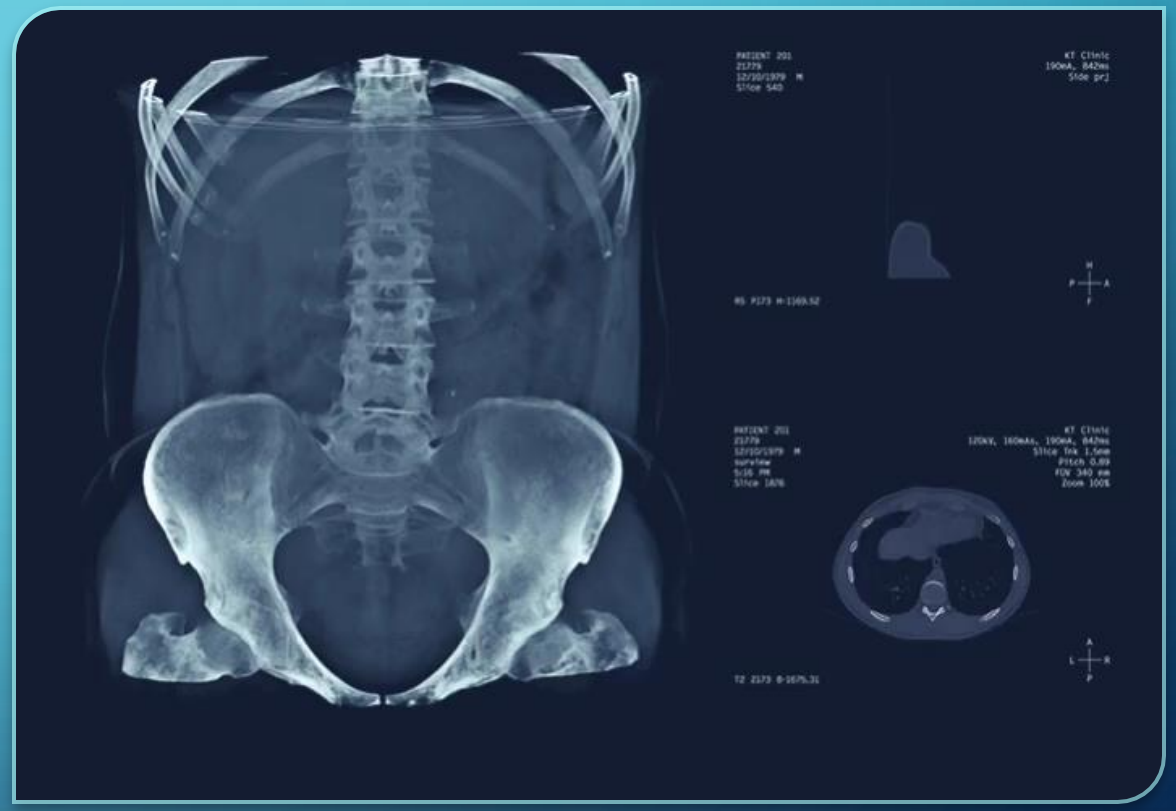
- Role of AI in medical imaging analysis
- Improved diagnostics and efficiency

- Artera.AI

- AI Doc

- AI rad companion

- https://f.hubspotusercontent40.net/hubfs/5748396/Website%20Assets/video/video%20for%20website%201.6.mp4



PREDICTIVE ANALYTICS

Deep phenotyping – large scale data and prediction of Complex traits with disease risk

Multi-omics profiling of large N cohorts

Outcomes data and socio-behavioral parameters

Mapping genetic overlap between different diseases involving shared pathogenic elements and comorbidity risks

Cardiovascular, autoimmunity, psychiatric disorders

"If you're teaching today what you were five years ago; either the field is dead or you are."

-- Noam Chomsky

21st century curricular emphasis

- **Knowledge capture and curation:** Teaching students to distinguish between information and knowledge. Stresses knowledge capture and curation not information retention.
- **Deep understanding of probabilistic reasoning:** understanding probabilities and communicating and applying them meaningfully
- **Collaboration with and management of AI applications**
- **Cultivation of empathy and compassion**

AI CONSIDERATIONS & STRATEGY

TELEMEDICINE AND REMOTE MONITORING

CHATBOTS AND VIRTUAL HEALTH ASSISTANTS

ETHICS AND PRIVACY CONCERNS

AI LIMITATIONS AND CHALLENGES

BEYOND AI: OTHER TECHNOLOGIES

BLOCKCHAIN TECHNOLOGY

INTERNET OF MEDICAL THINGS (IOMT)

AUGMENTED AND VIRTUAL REALITY (AR/VR)

BIG DATA ANALYTICS

CLOUD COMPUTING

DATA INTEGRATION AND INTEROPERABILITY

DEVELOPING A COMPREHENSIVE STRATEGY

EDUCATION AND TRAINING

COLLABORATIONS AND PARTNERSHIPS

FUNDING AND INVESTMENTS

AI STANDARDS AND ADOPTION
FUTURE TRENDS AND INNOVATIONS

Equity

Evidence

Sustainability

Policy

Education

"People Analytics" and Large Scale Databanks: Blurring the Boundaries Between Medical Research, Clinical Care and Daily Life

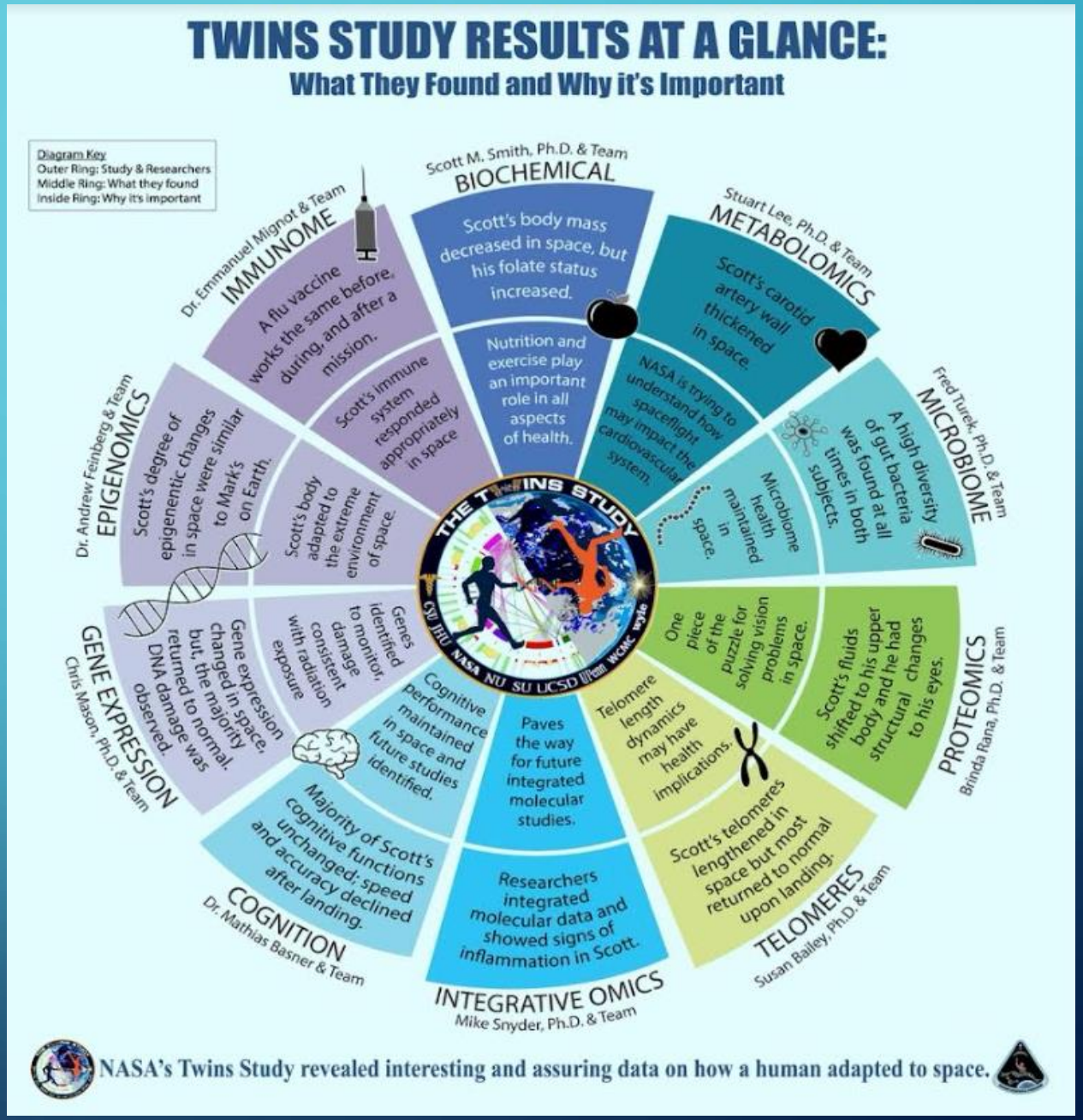
- every monitored event (clinical and non-clinical) is a potential data point
- every individual is a data node
- every individual is a research asset
- every individual is their own control

CASE STUDY #1

Real-world example of successfully managing medical information using AI and other technologies

NASA Twin Study of Mark and Scott Kelly who spent 340 days (at one time) on ISS

Total time in space was 520 days

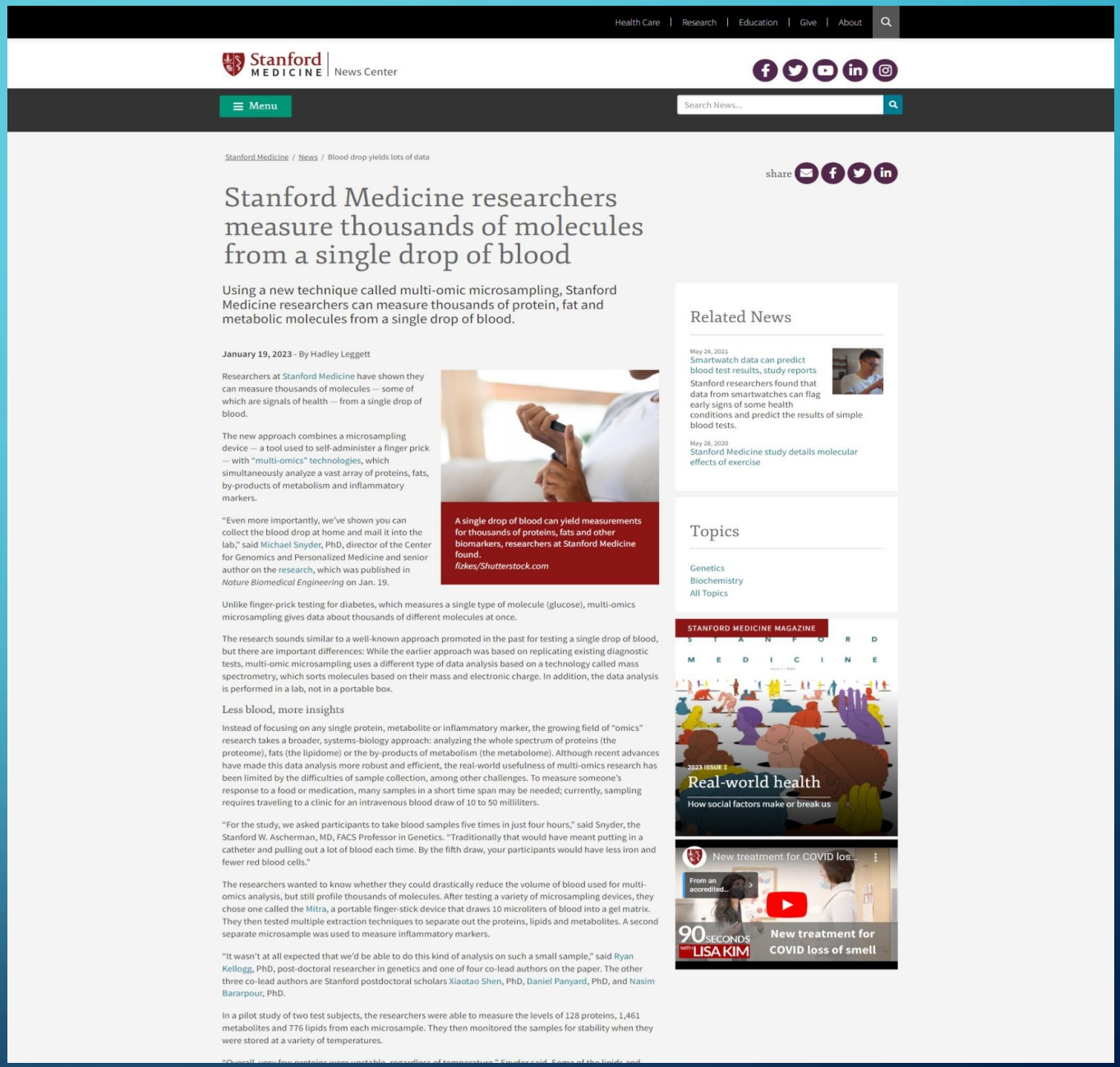


CASE STUDY #2

Importance of embracing AI and other technologies

Beauty of AI – may/can/will yield insights not initially obvious

These are early days!



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Stanford Medicine researchers measure thousands of molecules from a single drop of blood

Using a new technique called multi-omic microsampling, Stanford Medicine researchers can measure thousands of protein, fat and metabolic molecules from a single drop of blood.

January 19, 2023 - By Hadley Leggett

Researchers at Stanford Medicine have shown they can measure thousands of molecules — some of which are signals of health — from a single drop of blood.

The new approach combines a microsampling device — a tool used to self-administer a finger prick — with "multi-omics" technologies, which simultaneously analyze a vast array of proteins, fats, by-products of metabolism and inflammatory markers.

"Even more importantly, we've shown you can collect the blood drop at home and mail it into the lab," said Michael Snyder, PhD, director of the Center for Genomics and Personalized Medicine and senior author on the research, which was published in *Nature Biomedical Engineering* on Jan. 19.

A single drop of blood can yield measurements for thousands of proteins, fats and other biomarkers, researchers at Stanford Medicine found.
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Unlike finger-prick testing for diabetes, which measures a single type of molecule (glucose), multi-omics microsampling gives data about thousands of different molecules at once.

The research sounds similar to a well-known approach promoted in the past for testing a single drop of blood, but there are important differences: While the earlier approach was based on replicating existing diagnostic tests, multi-omic microsampling uses a different type of data analysis based on a technology called mass spectrometry, which sorts molecules based on their mass and electronic charge. In addition, the data analysis is performed in a lab, not in a portable box.

Less blood, more insights

Instead of focusing on any single protein, metabolite or inflammatory marker, the growing field of "omics" research takes a broader, systems-biology approach: analyzing the whole spectrum of proteins (the proteome), fats (the lipidome) or the by-products of metabolism (the metabolome). Although recent advances have made this data analysis more robust and efficient, the real-world usefulness of multi-omics research has been limited by the difficulties of sample collection, among other challenges. To measure someone's response to a food or medication, many samples in a short time span may be needed; currently, sampling requires traveling to a clinic for an intravenous blood draw of 10 to 50 milliliters.

"For the study, we asked participants to take blood samples five times in just four hours," said Snyder, the Stanford W. Ascherman, MD, FACS Professor in Genetics. "Traditionally that would have meant putting in a catheter and pulling out a lot of blood each time. By the fifth draw, your participants would have less iron and fewer red blood cells."

The researchers wanted to know whether they could drastically reduce the volume of blood used for multi-omics analysis, but still profile thousands of molecules. After testing a variety of microsampling devices, they chose one called the Mitra, a portable finger-stick device that draws 10 microliters of blood into a gel matrix. They then tested multiple extraction techniques to separate out the proteins, lipids and metabolites. A second separate microsample was used to measure inflammatory markers.

"It wasn't at all expected that we'd be able to do this kind of analysis on such a small sample," said Ryan Kellogg, PhD, post-doctoral researcher in genetics and one of four co-lead authors on the paper. The other three co-lead authors are Stanford postdoctoral scholars Xiaotao Shen, PhD, Daniel Panyard, PhD, and Nasim Bararpour, PhD.

In a pilot study of two test subjects, the researchers were able to measure the levels of 128 proteins, 1,461 metabolites and 776 lipids from each microsample. They then monitored the samples for stability when they were stored at a variety of temperatures.

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Stanford researchers found that data from smartwatches can flag early signs of some health conditions and predict the results of simple blood tests.

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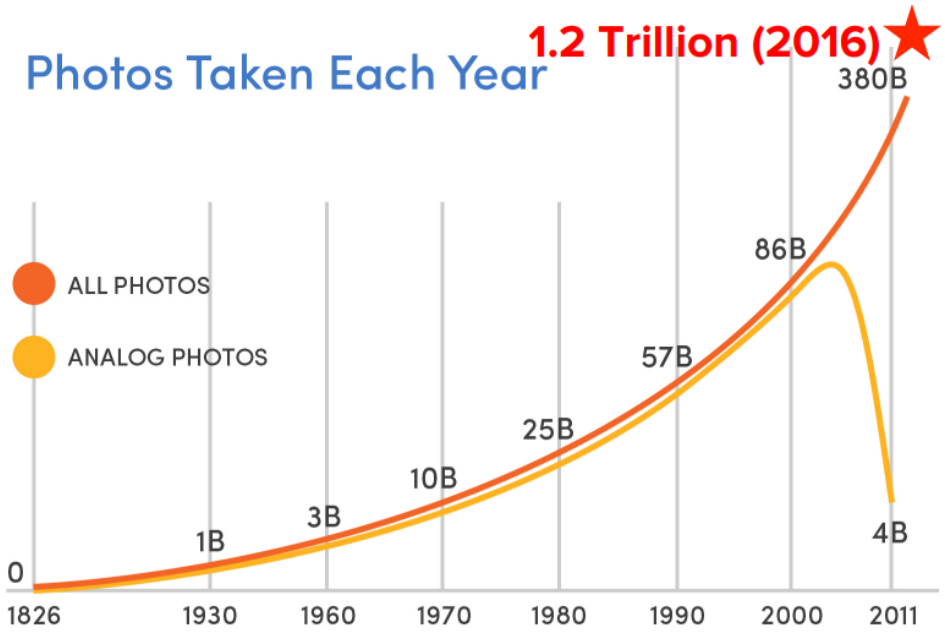


LINEAR → EXPONENTIAL

1996	2012	April 2012
MarketCap: **$28B**	***Bankrupt***	MarketCap: **$1B**
Employees: **140,000**	Employees: **17,000**	Employees: **13**

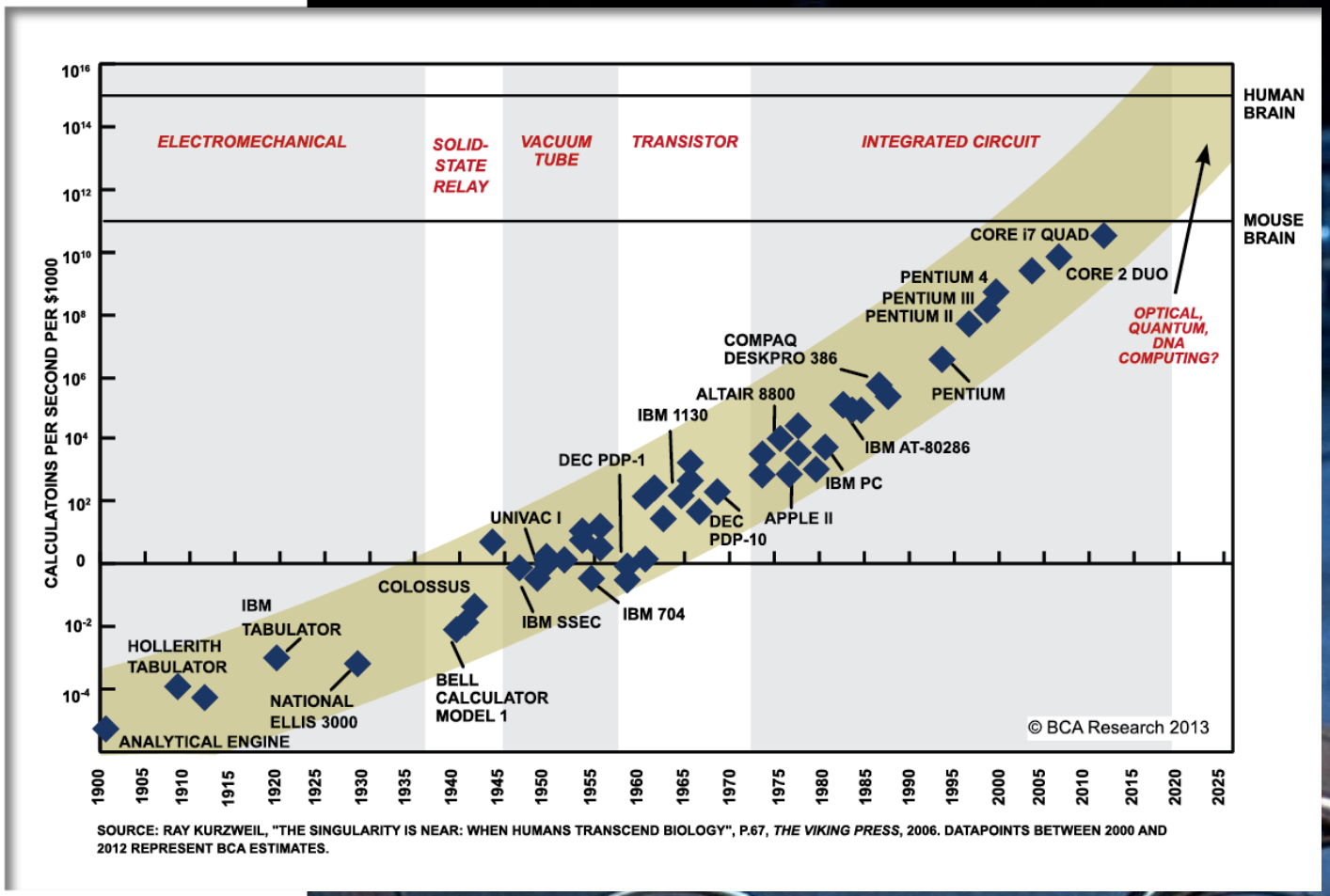
The average lifespan of a company listed in the S&P 500 has significantly decreased:

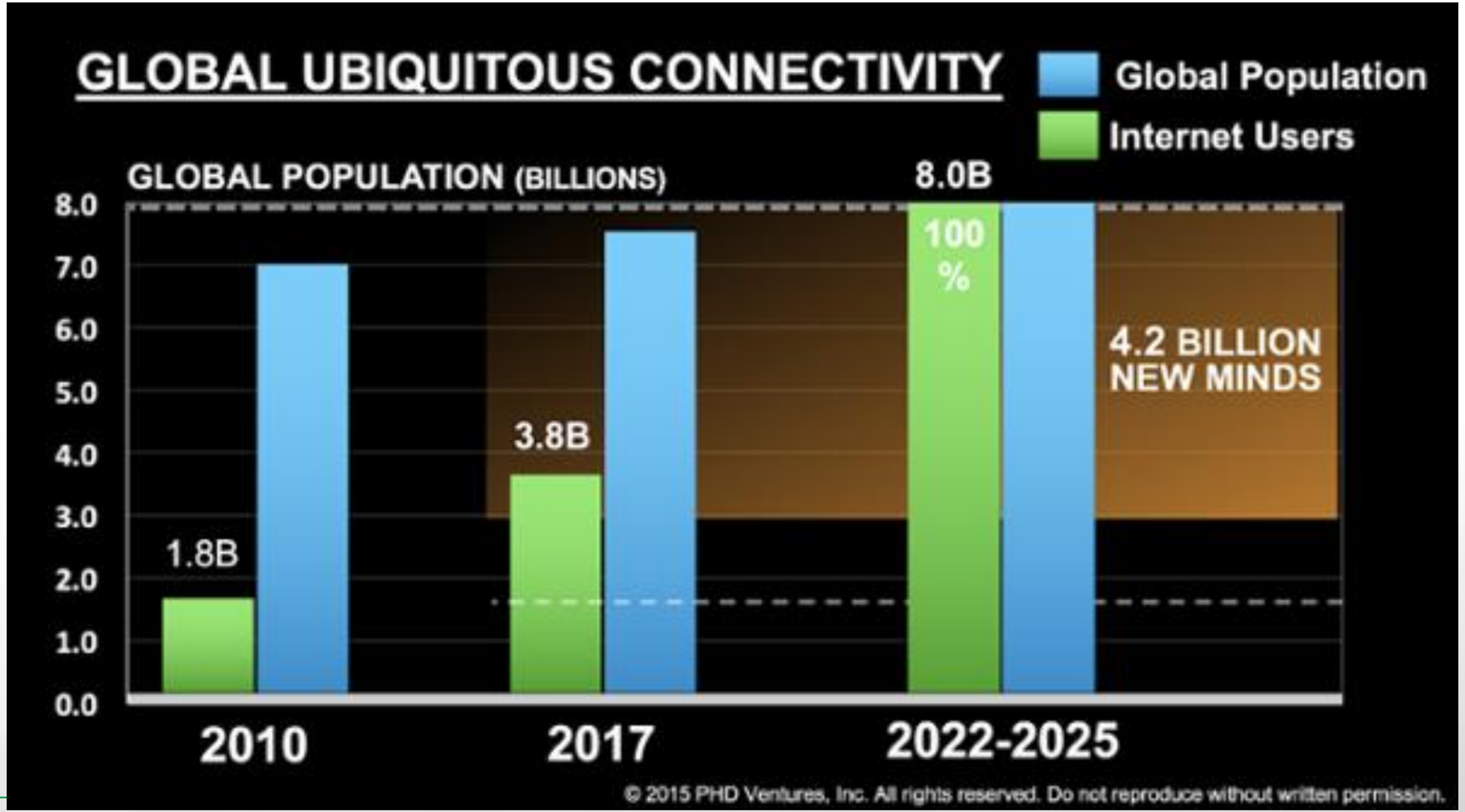
- **In the 1920's = 67 years**
- **Today = 15 years**

- Richard Foster, Yale University

The robots are coming.

Ray Kurzweil c. 2006





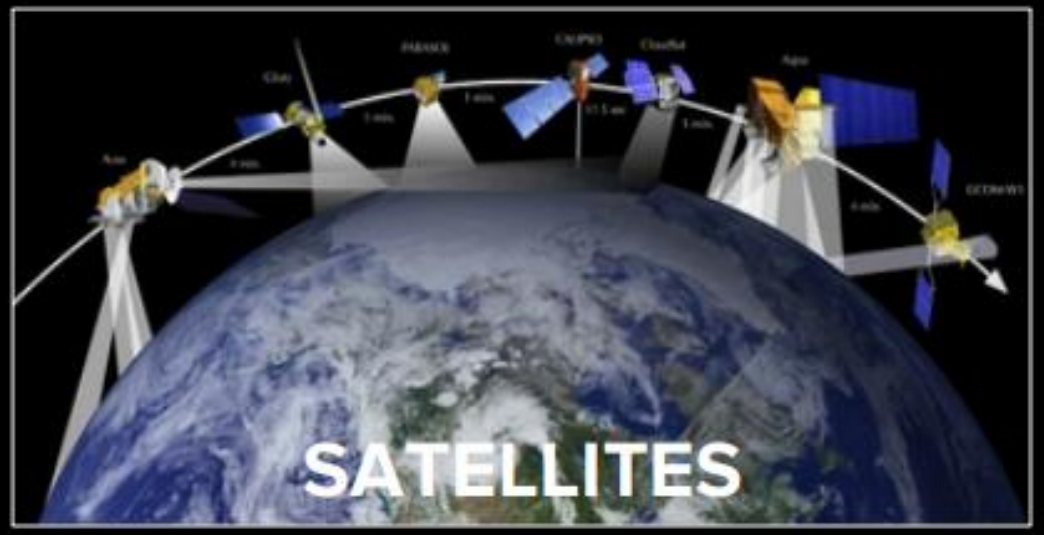
It's not just people being connected…

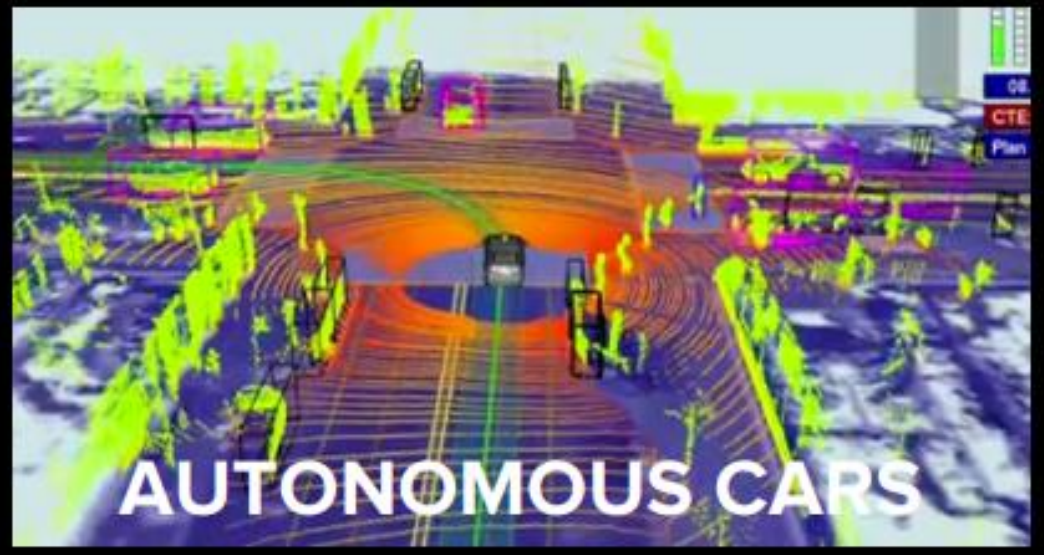
Global Connectivity will connect everything, everywhere, always → **The Internet of Everything.**

- **2015: 15 Billion** *(adding: 7 mil /day or 2.5 Billion/year)*
- **2020: > 50 Billion devices & 1 Trillion Sensors**
- **2030: > 500 Billion devices & 100 Trillion Sensors**

"Create a future of perfect knowledge, you can know anything you want, anytime, anywhere… Future of the DATA-DRIVEN COMPANY."

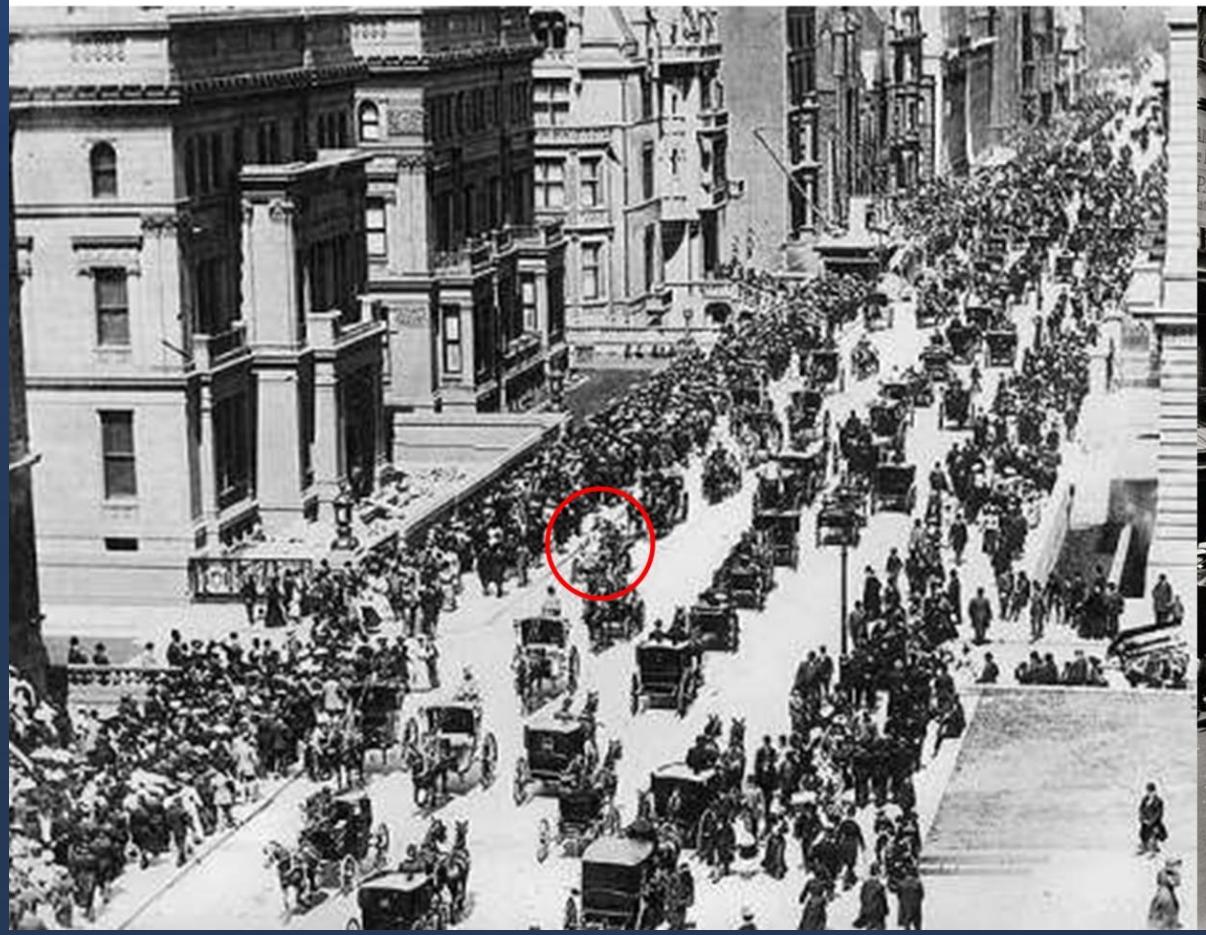
Know Anything, Anytime, Anywhere





Easter Parades in New York City

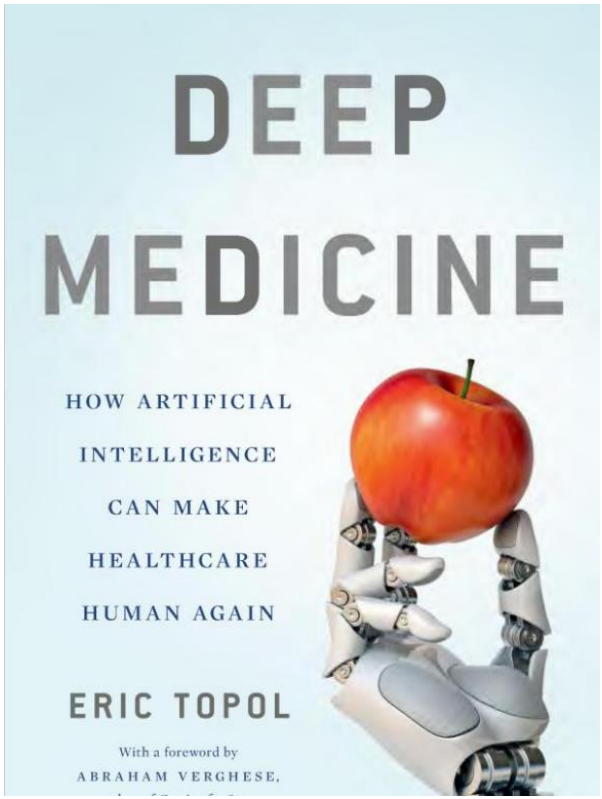
Year 1900: One Motor Vehicle

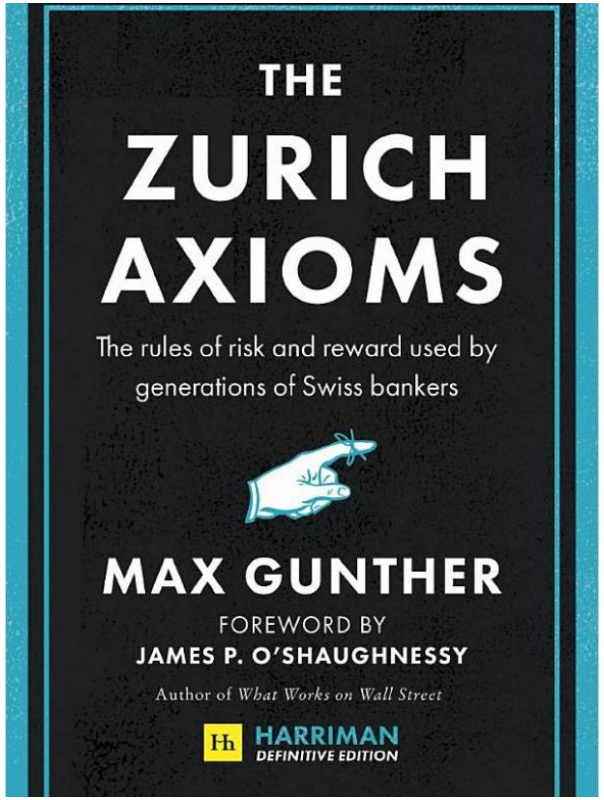


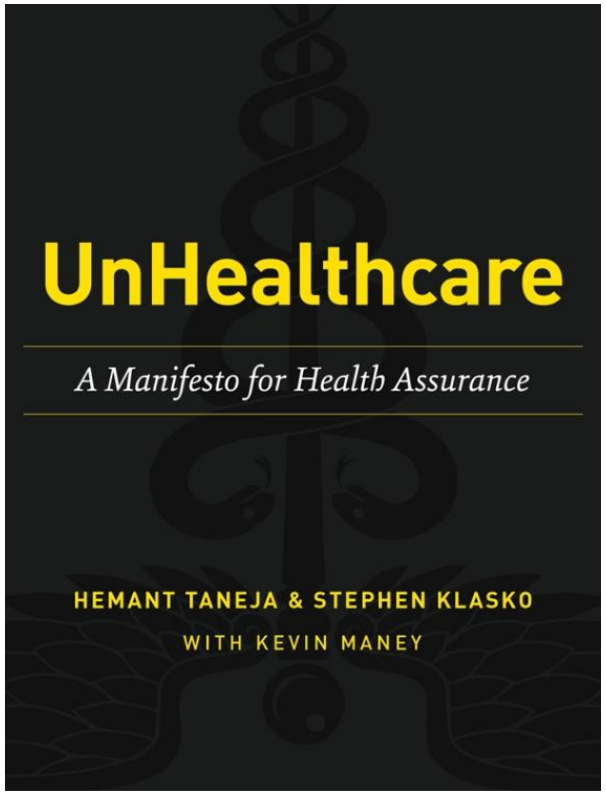
Year 1913: One Horse & Carriage

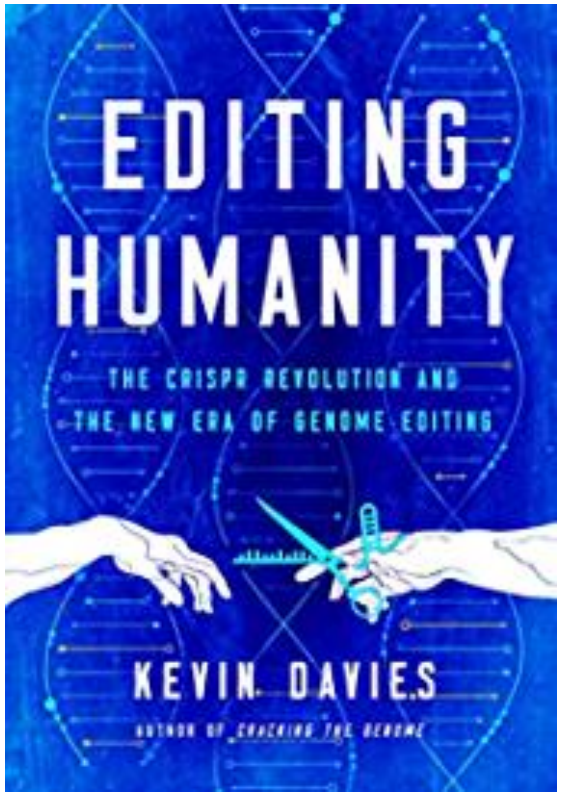
The future is bright!

Suggested reading










Thank you!

Questions?

Selected resources

- www.nccn.org
- https://accc-iclio.org
- www.cap.org
- www.cancerstaging.org
- www.sts.org
- www.astro.org
- www.asco.org
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