

A banner for the Virtual Human Global Summit II. It features a stylized, metallic, translucent human figure in a dynamic pose, with a glowing red heart and a cluster of pink, star-like particles to its right. The background is dark with a grid pattern.

Virtual Human Global Summit II

Accelerating Adoption of Virtual Human Twins in Healthcare.

The summit will be held in Barcelona, Spain with an alternate venue in New York City,
October 23-24, 2025

Building Patient Journey Lines: Lessons Learned and Opportunities for Molecular Driven Adaptive Learning Healthcare Systems

Jerry S.H. Lee, Ph.D.

Chief Science and Innovation Officer, Ellison Medical Institute

Associate Professor of Clinical Medicine, Chemical Engineering
and Material Sciences, Quantitative and Computational Biology,
and Health Innovation, University of Southern California

October 23rd, 2025



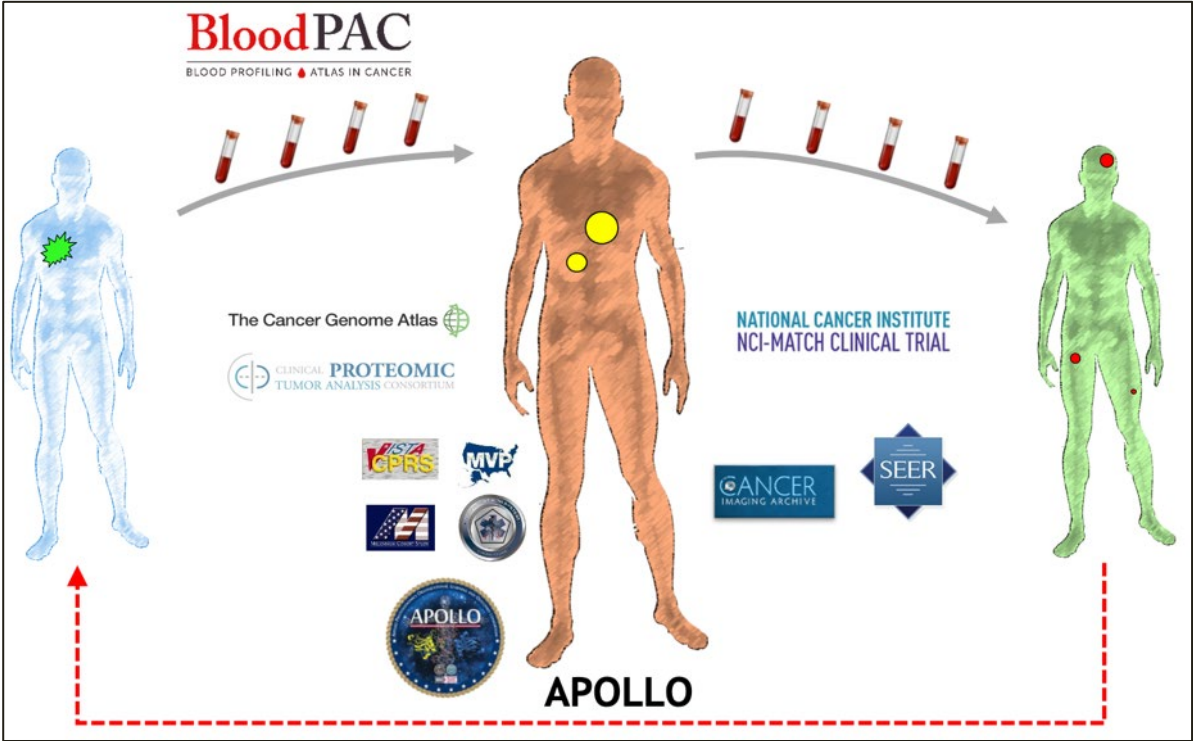
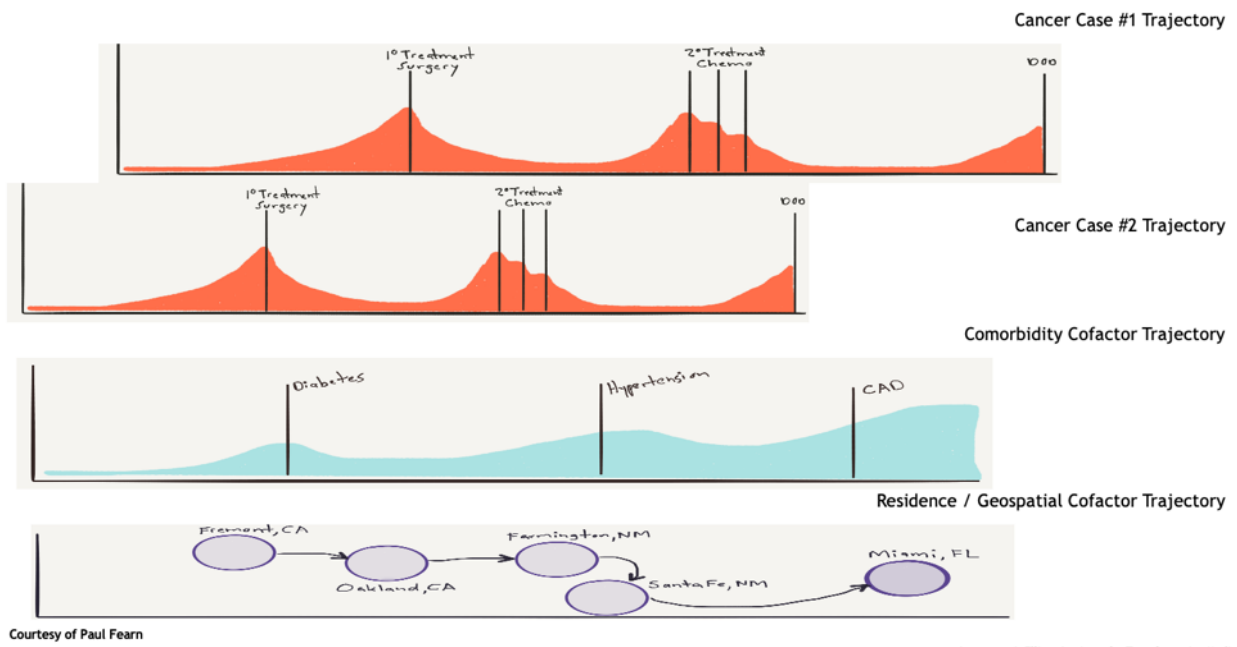
Ellison
Medical
Institute

Disclosure Statement

- Consultant to Murtha Cancer Center Director, Henry M. Jackson Foundation
- Scientific Advisory Board, AtlasXomics, Inc.
- Scientific Advisory Board, miRoncol, Inc.
- Advisory Board, Center for Computational Science Research, Inc.
- Co-founder, Blood Profiling Atlas in Cancer (BloodPAC) Consortium
- Chief Science and Innovation Officer, Ellison Medical Institute

From Virtual Human Global Summit I:

Need Patient Journey Lines/Trajectories: Cancer + Heath Factors



Don't reinvent wheels and build on public-private partnerships

SKIP RECAP



From Virtual Human Global Summit I:

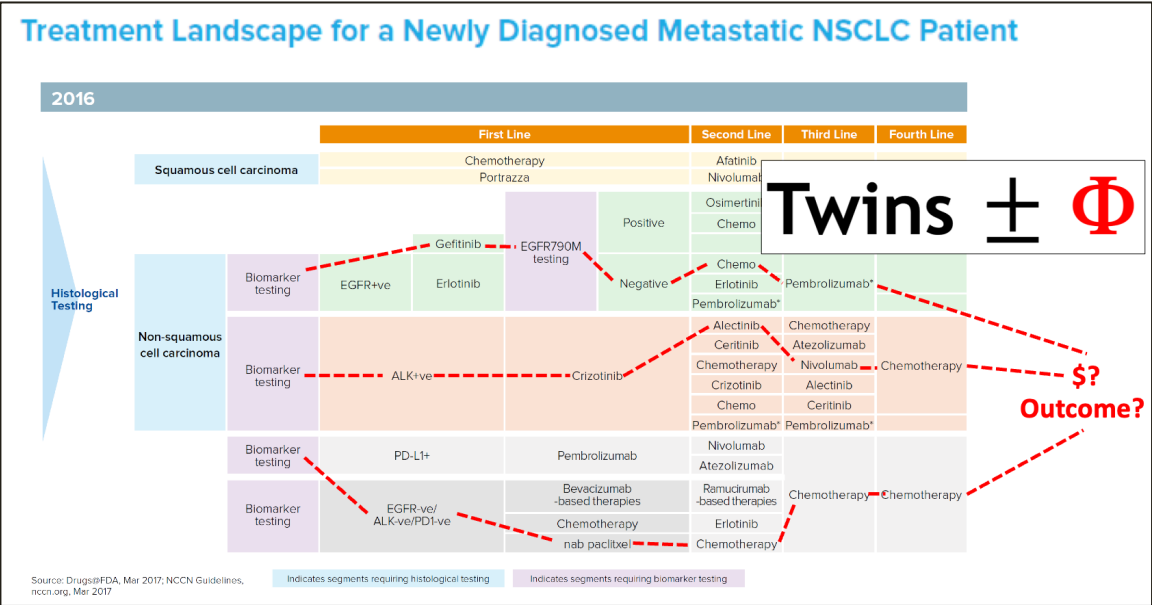
Twins ± Φ

(Fudge Factor)
(Forgiveness Factor)
(Functional Factor)

Variant Classification	
	Definition
Pathogenic	>99% certainty of being disease-causing
Likely pathogenic	>90% certainty of being disease-causing
Unknown significance	10–90% certainty of being disease-causing
Likely benign	Twins ± Φ >90% certainty of not being disease-causing
Benign	>99% certainty of not being disease-causing

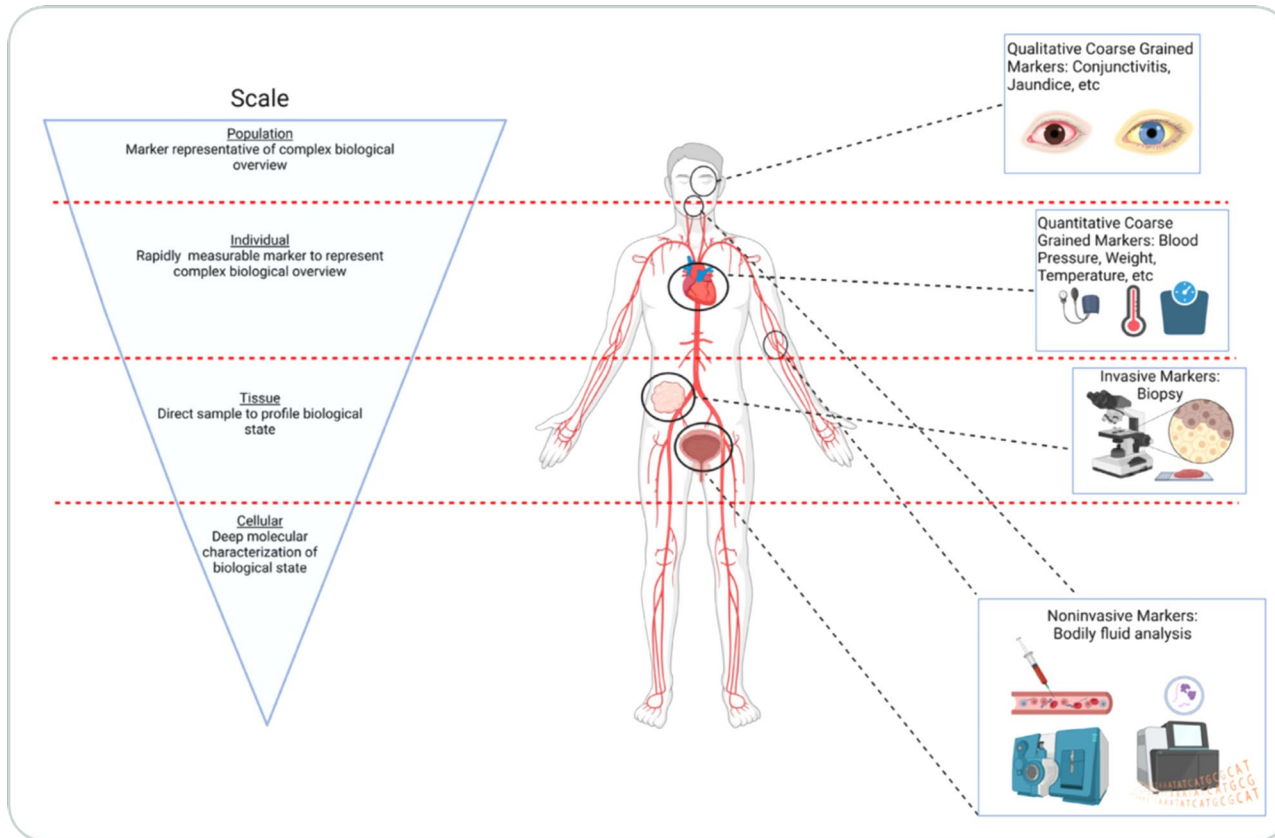
Table 2: Classifications of pathogenicity for genomic variants⁴⁸

Manolio et. al. Lancet, 2019



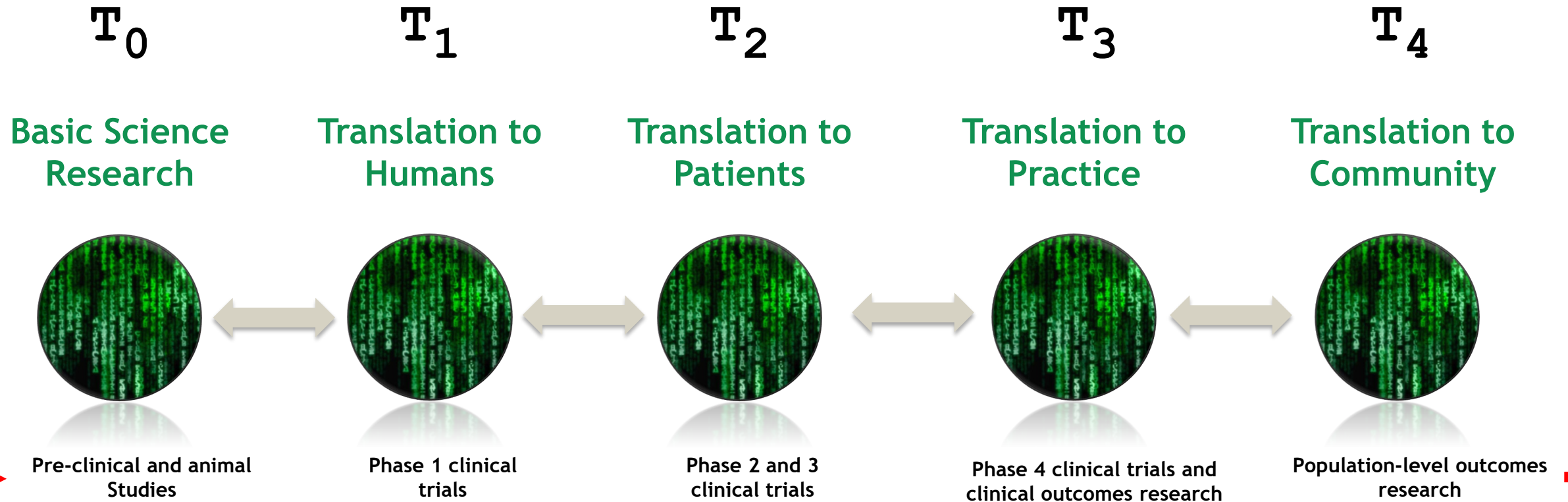
SKIP RECAP

Cancer-*ing*: emergent property of complex adaptive systems and require dynamic measurements of **states**



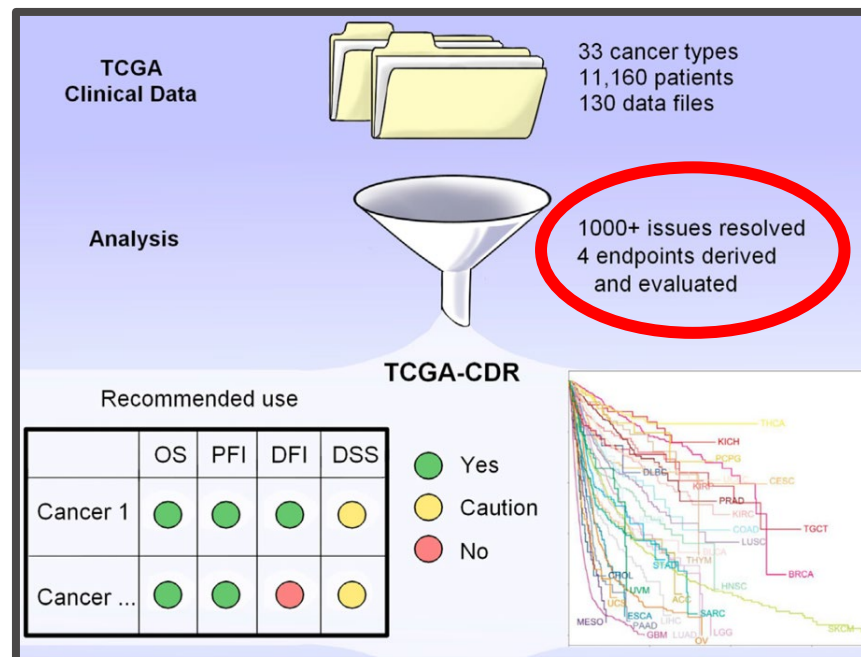
- **Redefine biomarkers to represent biological system states at different hierarchical levels of biological order**
 - Pattern recognition and coarse graining across scales
- **Use SoC clinical markers as orthogonal surrogates when developing new 'omics/AI candidate biomarkers**
 - Collaborate with clinicians to enable analysis of new results within context of prior studies
- **Contribute towards creation of longitudinal cohorts**
 - Limited vs. deidentified

Translation Data Spheres



When analyses are conducted without understanding the *context of data capture*, there is a risk of *inappropriate interpretation*, *lack of clinical relevance*, or lack of *feasible implementation* for broader impact.

An Integrated TCGA Pan-Cancer Clinical Data Resource to Drive High-Quality Survival Outcome Analytics



Craig D. Shriver, MD

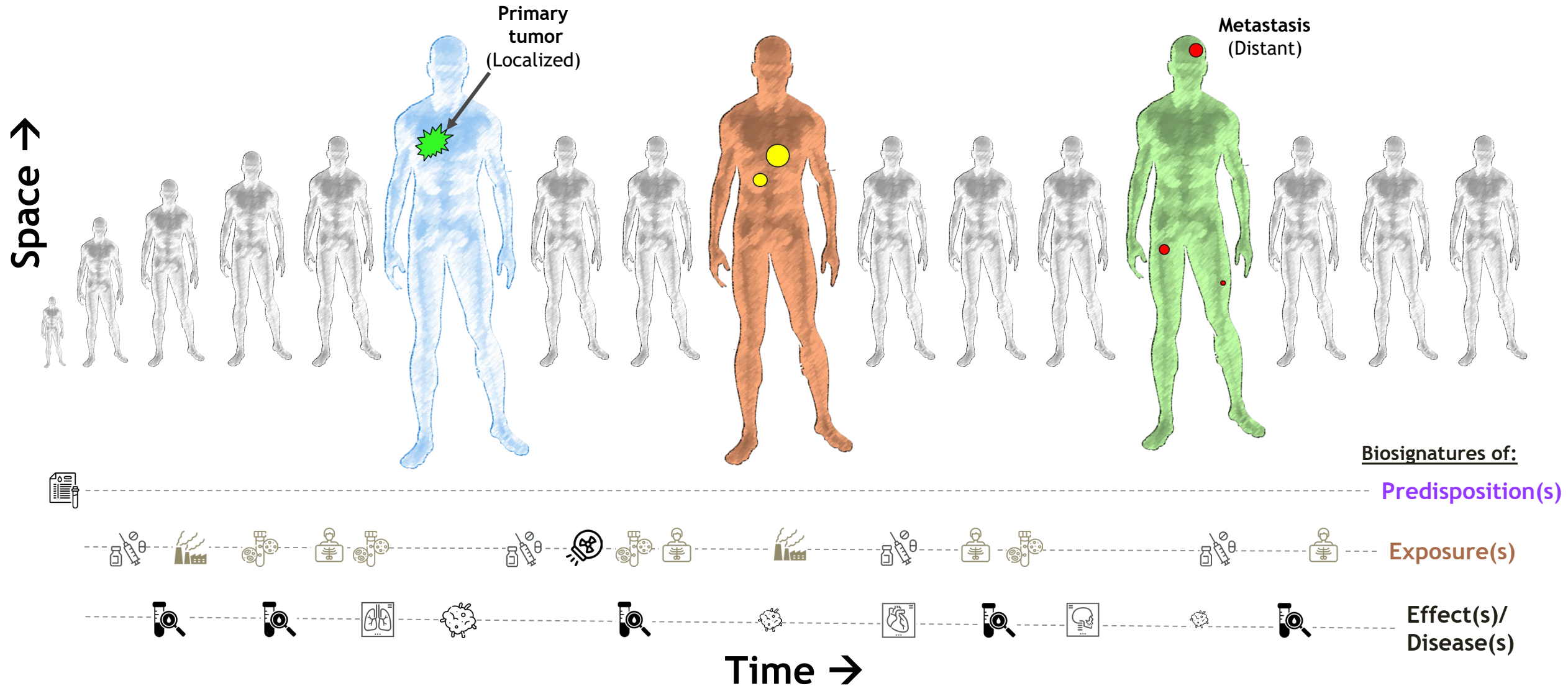


Hai Hu, PhD

Table 3. Assessment and Recommended Use of the Endpoints of OS, PFI, DFI, and DSS

Type	N	OS (Accurately Defined)			PFI (Accurately Defined)			DFI (Accurately Defined)			DSS (Approximately Defined)		
		Use	Event	Censored	Use	Event	Censored	Use	Event	Censored	Use	Event	Censored
ACC	92	Green	34	58	Green	49	43	Yellow	14	39	Green	app.	30 60
BLCA	412	Green	181	231	Green	177	235	Green	32	157	Green	app.	124 274
BRCA	1097	Yellow	151	946	Green	145	952	Green	84	869	Yellow	App.*	83 995
CESC	307	Green	71	236	Green	71	236	Green	26	150	Green	acc.	54 249
CHOL	45	Green	22	23	Green	23	22	Yellow	10	18	Yellow	app.*	18 24
COAD	459	Green	102	357	Green	123	336	Green	24	166	Green	app.	64 379
DLBC	48	Red	9	39	Yellow	12	36	Red	4	24	Red		4 44
ESCA	185	Green	77	108	Green	87	98	Green	23	66	Green	app.	51 132
GBM	596	Green	491	105	Green	506	90	Red	2	1	Green	app.	445 110
PCPG	179	Red	6	173	Red	21	158	Red	4	156	Red		4 175
PRAD	500	Yellow	10	490	Green	93	407	Green	30	310	Red		5 493
READ	170	Yellow	26	144	Green	39	131	Red	7	41	Yellow	app.*	15 149

Engineer's Dream: Develop A Continuum





Ellison Medical Institute

- Cancer & Preventive Care
- Research Laboratories
- CLIA-Certified Laboratory
- Think Tank & Education Center
- 80,000-Square-Foot Facility



Monitoring the rate and variability of somatic genomic alterations using long-read sequencing

scientific reports

Xingyao Chen¹, Hagai Ligumsky¹, Charlie Ambrose¹, Denisse Sibrian¹, Brian Tran¹, Daoud Arif¹, Olga Castellanos¹, Darren Kessner¹, Hanyi Luo¹, Mukta Ubale¹, Abigail Coleman¹, Vaidhyanathan Mahaganapathy¹, Thomas J. Jönsson¹, Reva K. Basho^{1,2}, Jerry S. H. Lee^{1,3,4,5}, Naim Matasci^{1,6}✉ & David B. Agus^{1,3,7}✉

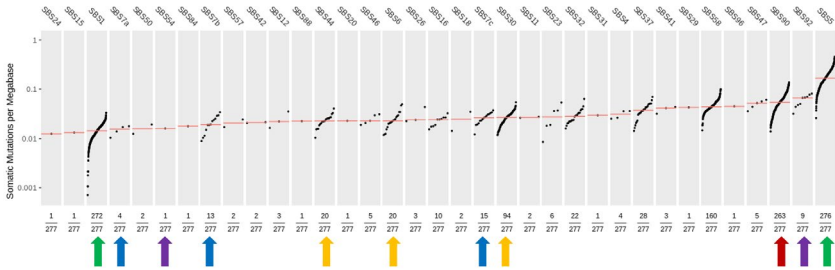
6/11/2025



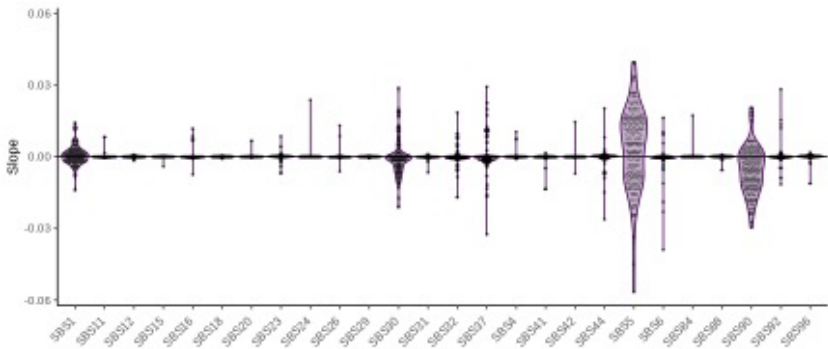
Cohort Breakdown



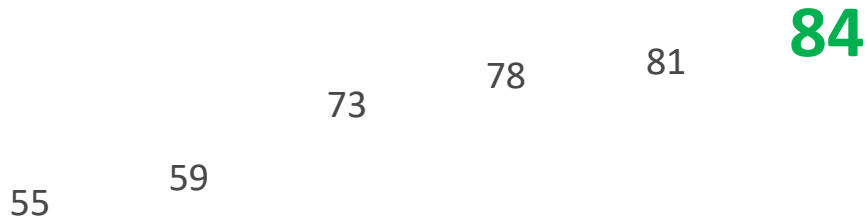
SBS signatures are not uniformly distributed across subjects, reflecting different exposures and intrinsic factors



For specific signatures, we can detect accumulation within the sampling period (6-12 months)



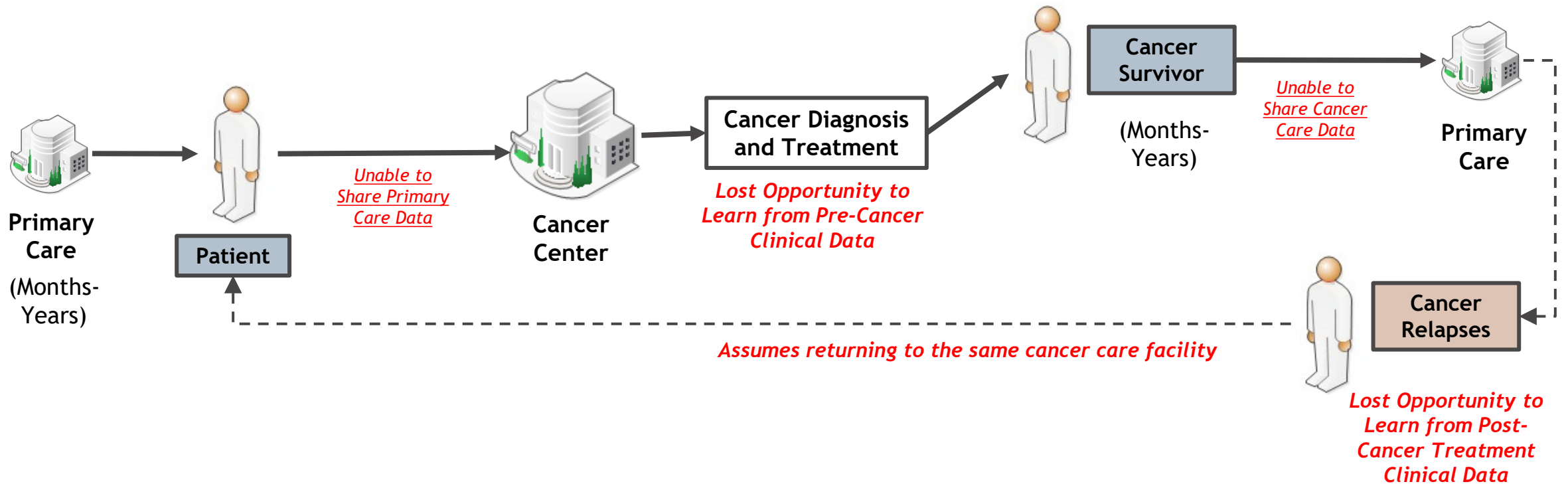
Still Learning: ACMG Secondary Findings



Predisposition(s)

Phenotypes	Gene(s)
Cancer (28)	v1.0 [2013]: TP53, APC, RET, BRCA1, BRCA2, MLH1, MSH2, MSH6, PMS2, MEN1, MUTYH, NF2, STK11, PTEN, RB1, TSC1, TSC2, VHL, WT1, SDHD, SDHAF2, SDHC, SDHB v.2.0 [2016]: BMPR1A, SMAD4 v3.0 [2021]: PALB2, MAX, TMEM127
Cardiovascular (41)	v1.0 [2013]: FBN1, TGFBF1, TGFBF2, SMAD3, ACTA2, MYH11, PKP2, DSP, DSC2, TMEM43, DSG2, RYR2, TNNT2, LMNA, COL3A1, LDLR, APOB, PCSK9, MYH7, MYBPC3, TNNI3, TPM1, MYL3, ACTC1, PRKAG2, MYL2, KCNQ1, KCNH2, SCN5A v3.0 [2021]: CASQ2, TRDN, FLNC, TTN v3.1 [2022]: BAG3, DES, RBM20, TNNC1 v3.2 [2023]: CALM1, CALM2, CALM3 v3.3 [2025]: PLN
Metabolism (6)	v1.0 [2013]: GLA v.2.0 [2016]: OTC v3.0 [2021]: GAA, BTBD v3.3 [2025]: CYP27A1, ABCD1
Miscellaneous (9)	v1.0 [2013]: RYR1, CACNA1S v.2.0 [2016]: ATP7B v3.0 [2021]: HFE, ACVRL1, ENG, HNF1A, RPE65 v3.1 [2022]: TTR

Without a National Learning Healthcare System for Cancer



“~85% of cancer patients are first diagnosed and treated in community setting”

Copur et. al. J. Onc. Practice, 2015



Federal EHR Status as of July 2025



138 of 138
**Parent Military
Treatment Facilities**
(3,628 DOD Locations)
(100% Complete)



6 of 170
VA Medical Centers
(26 associated clinics and
104 remote services)
(3.5% Complete)



110
USCG Sites
(100% Shoreside Complete)



7
NOAA Sites
(100% Complete)



207,000+
Federal EHR Users
(Clinicians, Nurses, Etc.)
(Total Number of
Users Fluctuates)



8.5M+
**Unique Patients
Currently in the
Federal EHR**

Murtha Cancer Center (MCC)

DoW Cancer Center of Excellence

MCC Research Program (MCCRP)

Approximately **1,500 new cases** of all types of cancer per year in Active Duty Service Members

Source: www.afhsb.mil

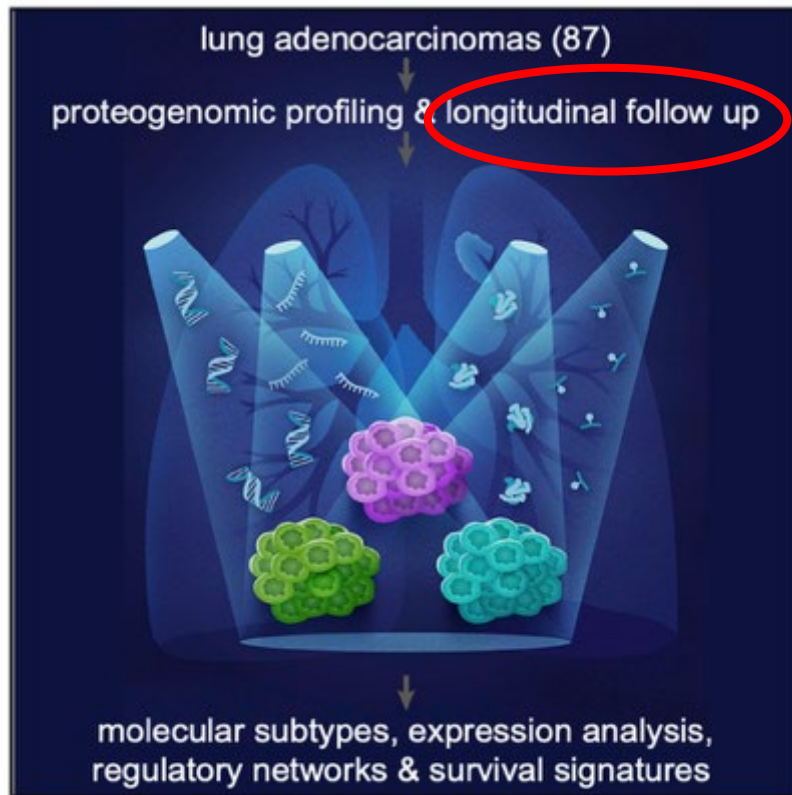


MISSION:

Improve the diagnosis and multidisciplinary treatment of DoW cancer patients through innovative clinical research, care, and education. Through coordination and alignment with tri-service cancer research initiatives throughout the MHS, the MCCRP enhances the readiness of the military, its families, and beneficiaries. The MCCRP employs the unique resources of the DoW leveraged with other Federal and civilian partners to enhance cancer care for SM and DoW beneficiaries.

VISION:

As the **only DoW-designated** Cancer Center of Excellence, the Murtha Cancer Center is the nexus of cancer services and support for the MHS with clinical and translational research cancer programs fully integrated with USU, NCI, and VA.



Highlights

- Lung adenocarcinoma has three subtypes defined by genome alteration profiles
- Tumors with greater immune content have reduced RNA:protein correlation
- Protein and RNA signatures predicting survival of patients are identified
- Phosphoproteomic networks identify potential therapeutic vulnerabilities among subtypes

Cell Reports Medicine

CellPress
OPEN ACCESS

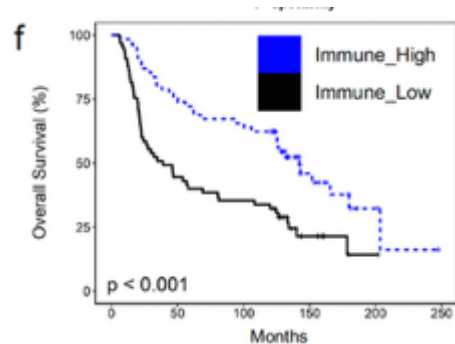
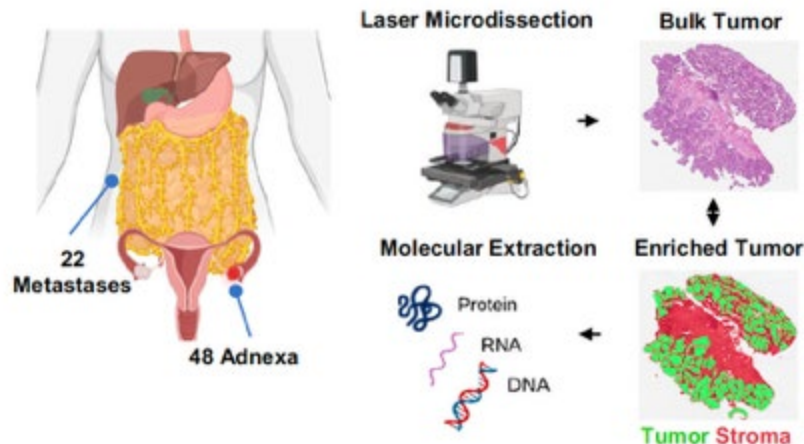
Article

Proteogenomic analysis of lung adenocarcinoma reveals tumor heterogeneity, survival determinants, and therapeutically relevant pathways

Anthony R. Soltis,^{1,2} Nicholas W. Bateman,^{2,3,4} Jianfang Liu,⁵ Trinh Nguyen,⁶ Teri J. Franks,⁷ Xijun Zhang,^{1,2} Clifton L. Dalgard,¹ Coralie Violette,^{1,2} Stella Somiari,⁵ Chunhua Yan,⁶ Karen Zeman,^{8,9} William J. Skinner,^{8,9} Jerry S.H. Lee,^{2,8,10,11} Harvey B. Pollard,¹ Clessen Turner,⁹ Emanuel F. Petricoin,¹² Daoud Meerzaman,⁵ Thomas P. Conrads,^{3,4} Hai Hu,^{5,9} APOLLO Research Network, Craig D. Shriver,^{9,*} Christopher A. Moskaluk,^{13,*} Robert F. Browning, Jr.,^{8,9,*} and Matthew D. Wilkerson^{1,14,*}



Proteogenomic analysis of enriched HGSOC tumor epithelium identifies prognostic signatures and therapeutic vulnerabilities



Nicholas W. Bateman^{1,2,3,32}✉, Tamara Abulez^{1,2}, Anthony R. Soltis⁴, Andrew McPherson⁵, Seongmin Choi⁵, Dale W. Garsed^{6,7}, Ahwan Pandey⁶, Chunqiao Tian^{1,2}, Brian L. Hood^{1,2}, Kelly A. Conrads^{1,2}, Pang-ning Teng^{1,2}, Julie Oliver^{1,2}, Glenn Gist^{1,2}, Dave Mitchell^{1,2}, Tracy J. Litzi^{1,2}, Christopher M. Tarney¹, Barbara A. Crothers⁸, Paulette Mhaweche-Fauceglia⁹, Clifton L. Dalgard¹⁰, Matthew D. Wilkerson⁴, Mariaelena Pierobon¹⁰, Emanuel F. Petricoin¹⁰, Chunhua Yan¹¹, Daoud Meerzaman¹¹, Clara Bodelon¹², Nicolas Wentzensen¹², Jerry S. H. Lee¹³, The APOLLO Research Network*, David G. Huntsman¹⁴, Sohrab Shah¹⁵, Craig D. Shriver³, Neil T. Phippen¹, Kathleen M. Darcy^{1,2,3}, David D. L. Bowtell^{6,7}, Thomas P. Conrads^{1,3,15,32}✉ & G. Larry Maxwell^{1,3,15,32}✉

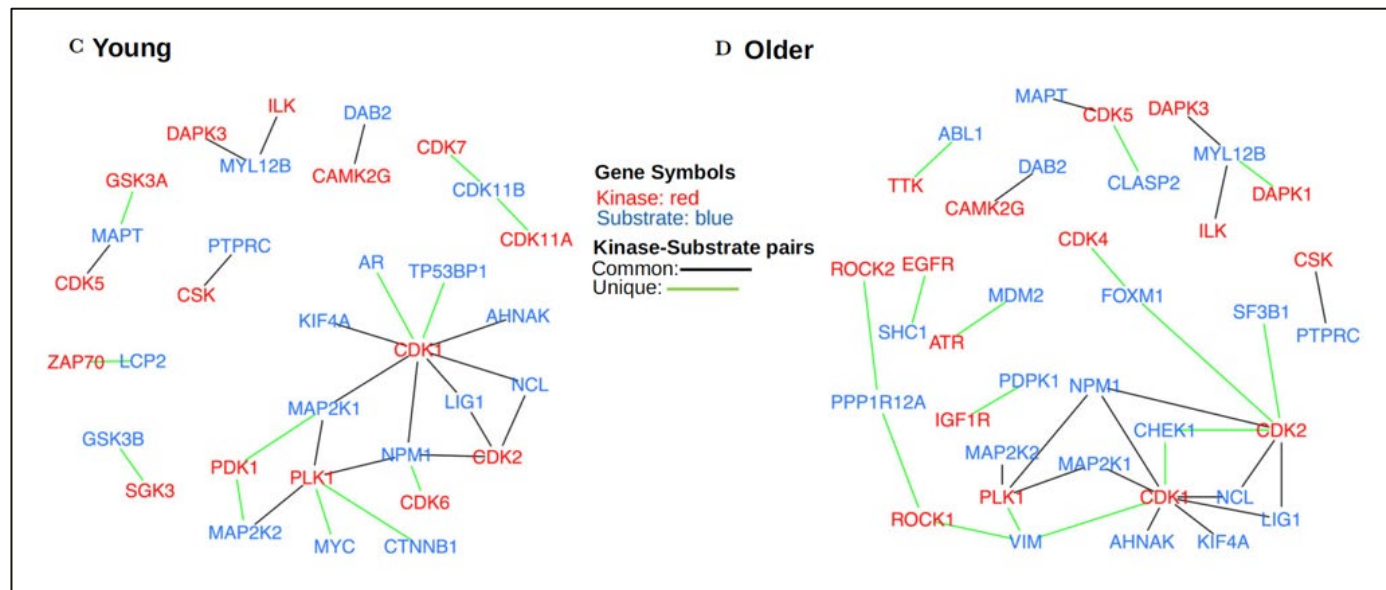



<https://doi.org/10.1038/s41523-025-00793-0>

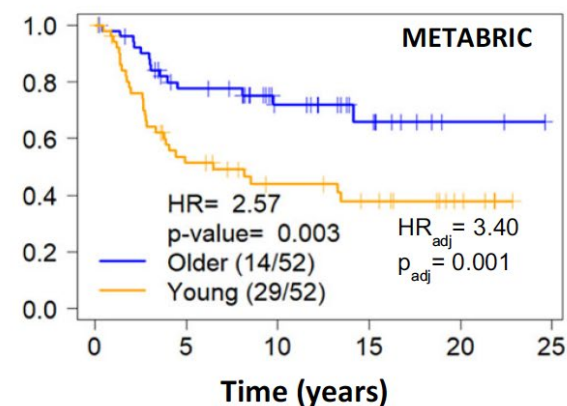
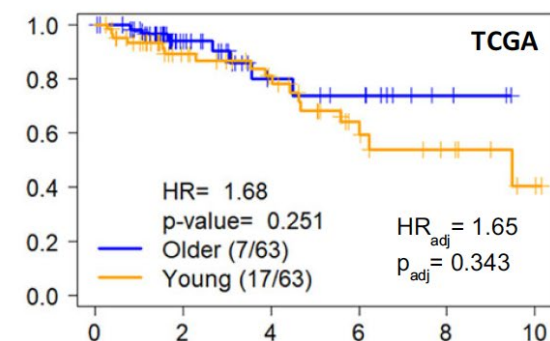
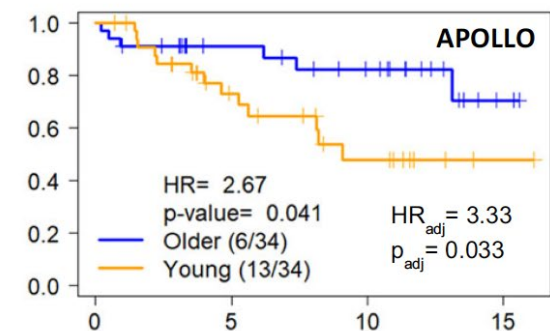
Proteogenomic characterization of invasive breast tumors in young women

Praveen-Kumar Raj-Kumar^{1,2}, Jianfang Liu^{1,10}, Anthony R. Soltis^{1,4,10}, Nicholas W. Bateman^{2,4,5,10}, Qingrong Chen^{6,10}, Lori A. Sturtz^{1,2,10}, Brenda Deyarmin¹, Mariaelena Pierobon⁷, Tamara A. Abulez^{2,4,5}, Anupama Praveen-Kumar¹, Xijun Zhang^{3,4}, Trinh Nguyen⁸, Chunhua Yan⁹, Ying Hu⁹, Kate Guion², Jeffrey A. Hooke^{2,4}, Albert J. Kovatich^{2,4}, Leigh Fantacone-Campbell^{2,4}, Brad Mostoller¹, Leonid Kvecher^{1,2}, Stella Somiani¹, Patricia S. Steeg⁹, Padma Sheila Rajagopal¹⁰, Kathleen M. Darcy^{2,4,5}, Jerry S. H. Lee^{2,4,5,11}, Clifton L. Dalgard², Thomas P. Conrads^{12,13}, Emanuel F. Petricoin¹, Daoud Meerzaman⁶, Matthew D. Wilkerson⁹, APOLLO Research Network⁴, Xiaoying Lin^{1,2}, Craig D. Shriver^{2,12}, Stanley Lipkowitz² & Hai Hu^{1,2}✉

08/18/2025

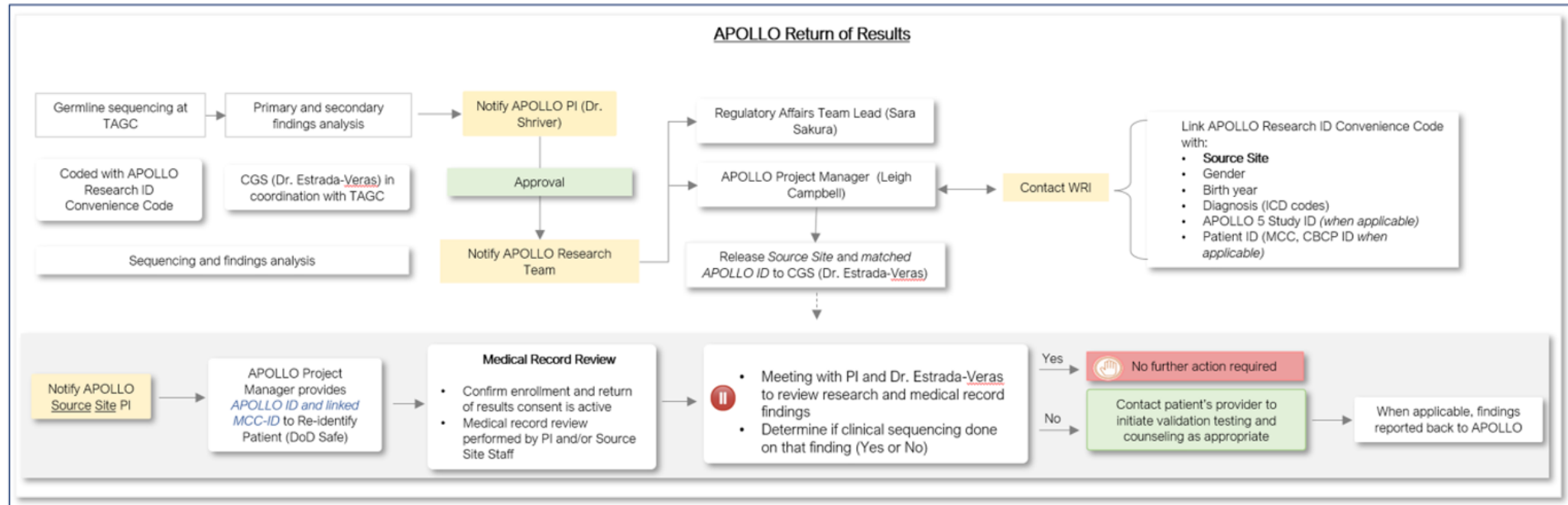


B. K-M Plots of Progression-Free Interval

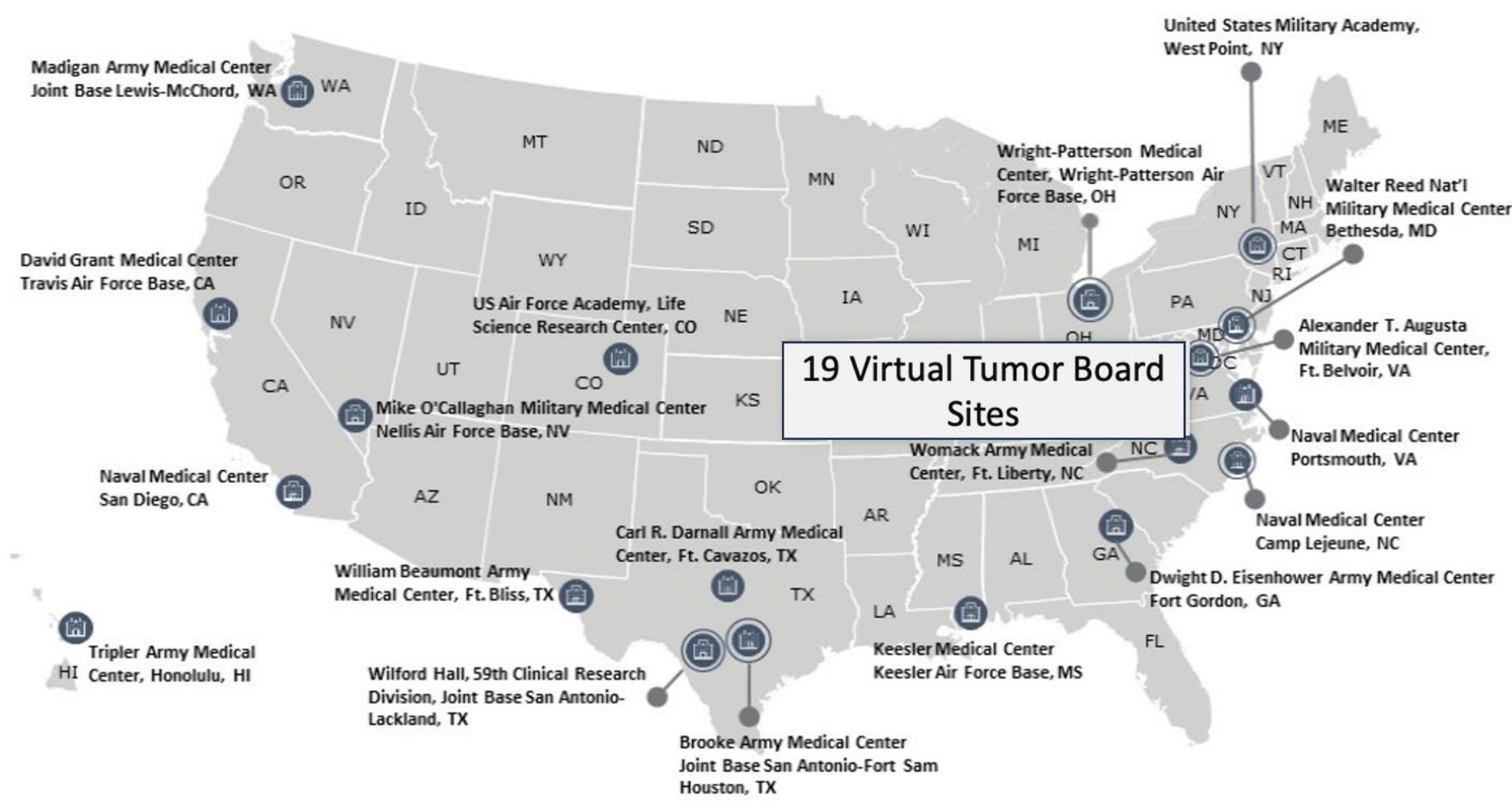


APOLLO Return of Genetic Results Program

- Genome analysis on normal (whole blood) and tumor tissue-derived DNA is performed through APOLLO 5.
- Participants consent for return of clinically actionable results identified in **primary (cancer)** and **secondary findings (non-cancer)** genes.
- When a clinically actionable finding is identified, the APOLLO study PI is notified by the APOLLO-CGS. The APOLLO study PI then initiates the process of determining the enrollment site for that study participant.
- The intent to return genetic results to an APOLLO participant workflow is triggered.
- Once the source site has been determined, a discussion is arranged between the source-site PI and the Head Clinical Geneticist for the MCCRP (Geneticist for APOLLO CGS) for discussion and next steps.



Virtual Rectal Adenocarcinoma Watch and Wait Tumor Board Sites



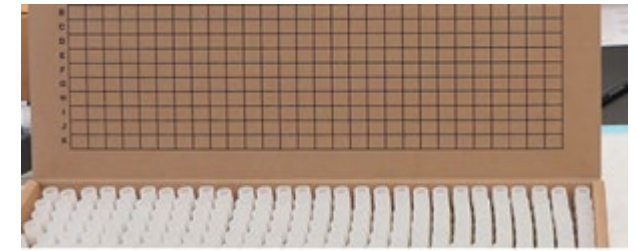
Department of Defense Serum Repository

The Department of Defense Serum Repository was established in 1989 as the Army/Navy Serum Repository for storing serum that remained following mandatory HIV testing within the active and reserve components of the Army, Navy, and Marines. Since that time, the mission of the DODSR has expanded to include the collection and storage of operational deployment specimens as well as Air Force specimens.

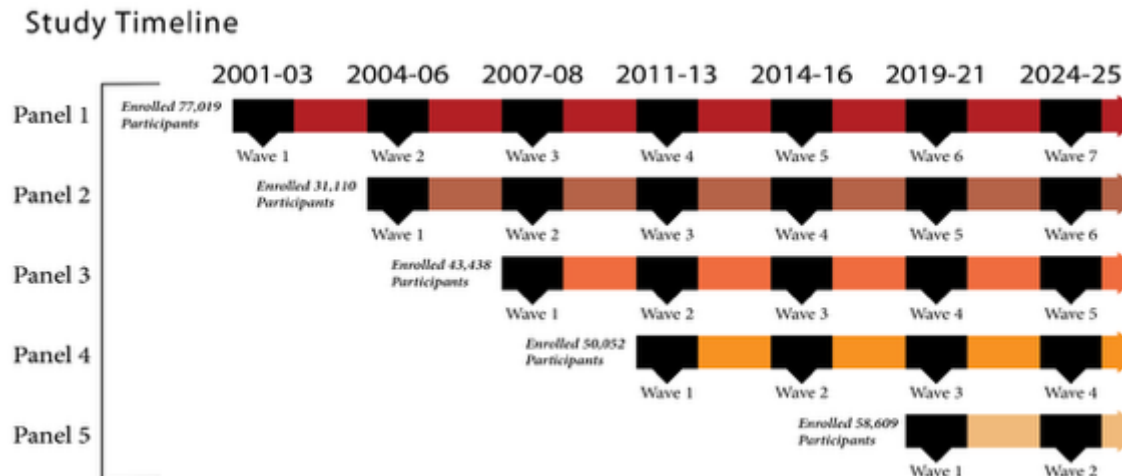
The DODSR

- Is a secure facility maintained by the Armed Forces Health Surveillance Division.
- Currently houses more than 74 million serial blood-derived serum specimens in large state-of-the-art walk-in freezers, and continues to grow by approximately 2.0 million specimens per year.

<https://www.health.mil/Military-Health-Topics/Health-Readiness/AFHSD/Functional-Information-Technology-Support/Department-of-Defense-Serum-Repository>

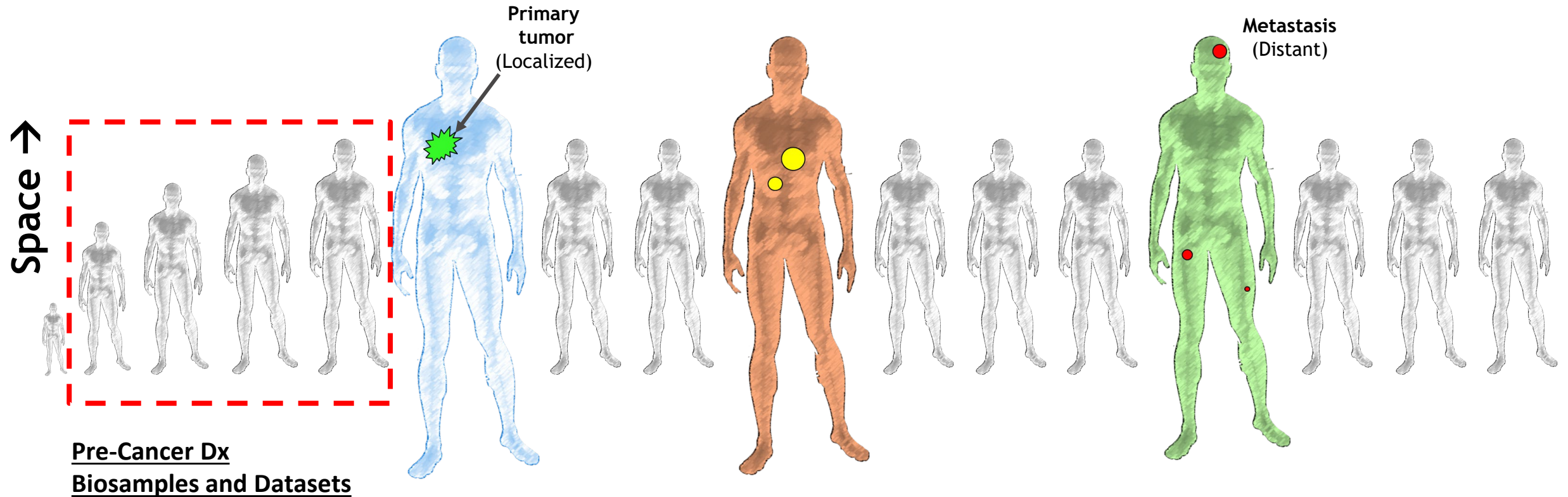


<https://www.millenniumcohort.org>



<https://www.mvp.va.gov>

Engineer's Dream: Develop A Continuum



- Predisposition (molecular)
- Lifestyle (surveys, CWD)
- Health records and family history
- Operational history

Time →

PROMETHEUS



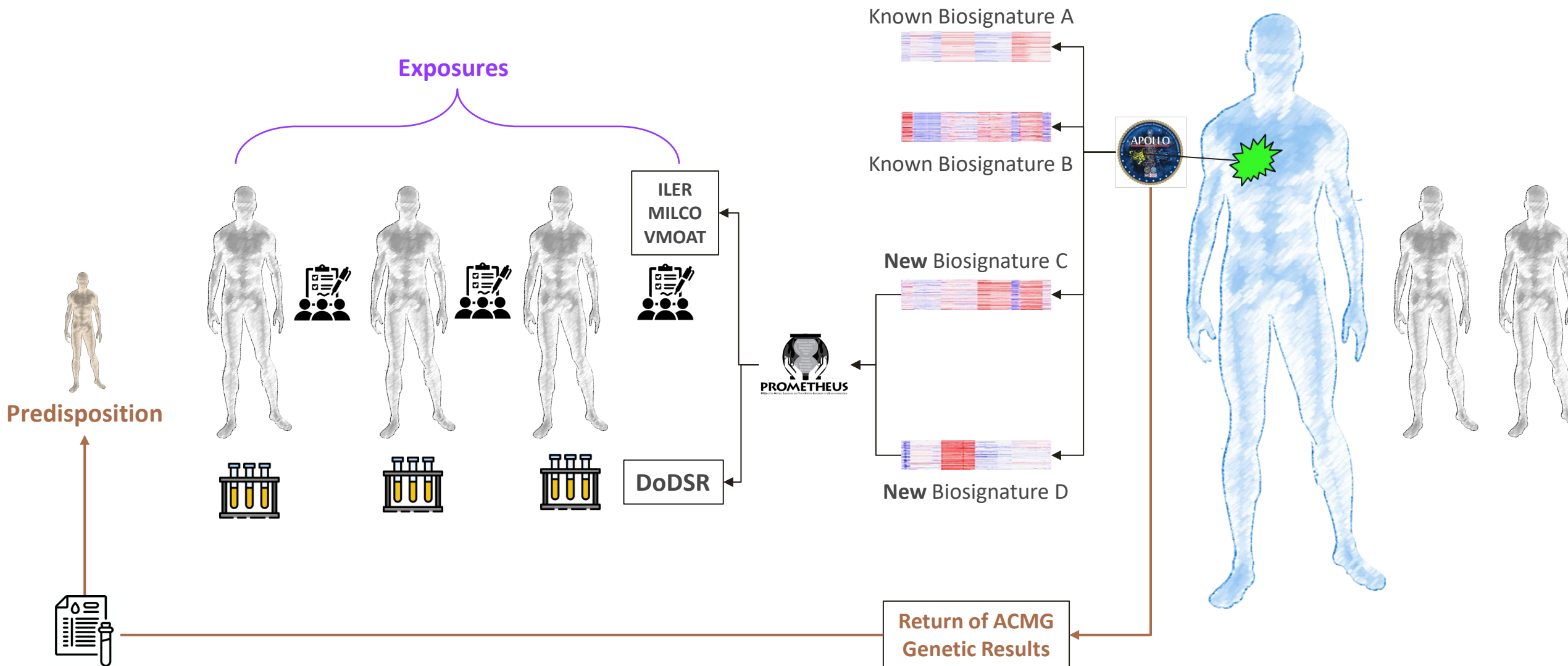
Goal – Discover advanced precision oncology technologies that will enable prevention, early detection, and enhanced treatments of cancers arising from exposures to environmental contaminants and toxin hazards so military service members are returned to duty, re-classified to a new duty position, or reintegrated into civilian/Department of Veterans Affairs (VA) life with the highest possible quality of life.

Vision – Integrated federal scientific platforms with **public-private innovators** revealing the impact of service-related exposures to environmental contaminants and toxin hazards and developing prevention and early detection approaches and advanced treatments of cancers arising from these exposures.



Murtha Cancer Center Research Program Longitudinal Cohorts

Predisposition, Exposures, and Disease(s)



The Joint Pathology Center



The world's largest repository of glass slides and paraffin embedded tissues

- >55 million slides
- >31 million paraffin tissue blocks
- ~500,000 tissue specimens
- Two Major collections
 - Central ~ 3.8 million cases
 - Base Realignment and Closure (BRAC)



Central Collection

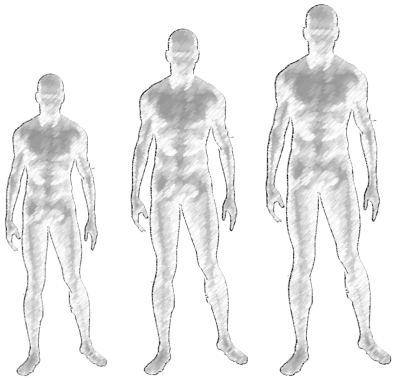


Improving Health and Building Readiness. Anytime, Anywhere — Always

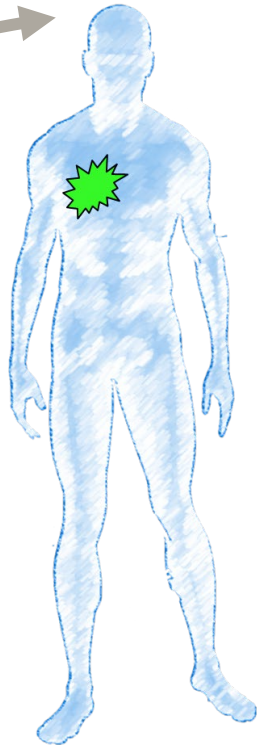


BloodPAC

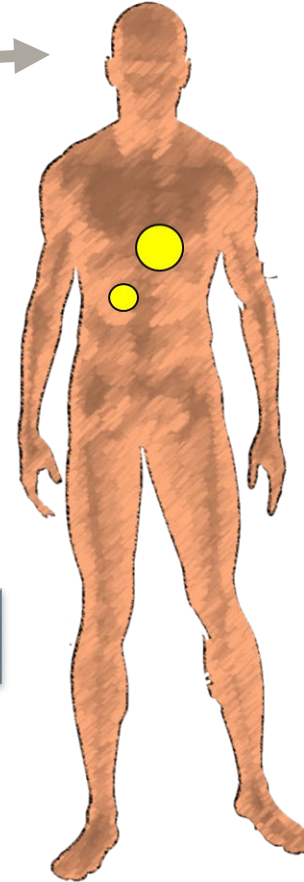
BLOOD PROFILING • ATLAS IN CANCER



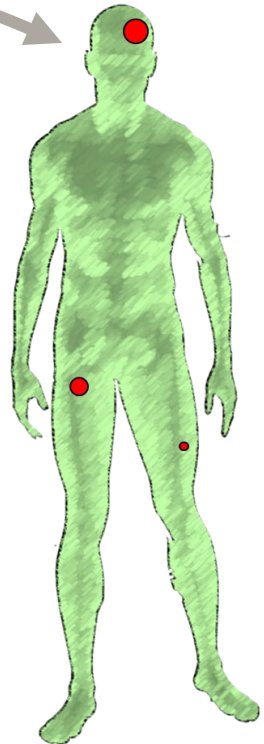
**Pre-Cancer Dx VA/DoD
Biosamples and Datasets**



The Cancer Genome Atlas

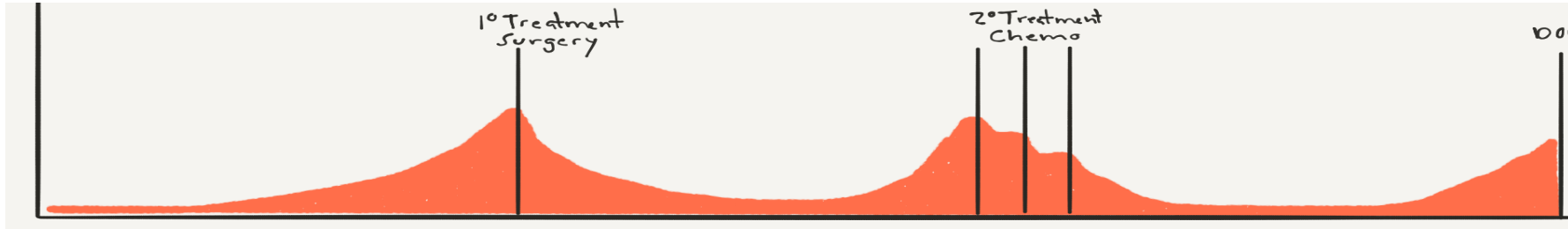


NATIONAL CANCER INSTITUTE
NCI-MATCH CLINICAL TRIAL

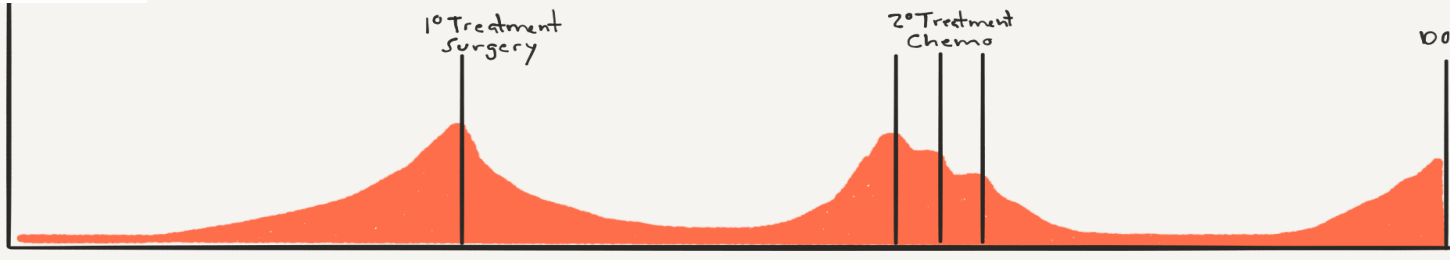


Need Patient Journey Lines/Trajectories: Cancer + Heath Factors

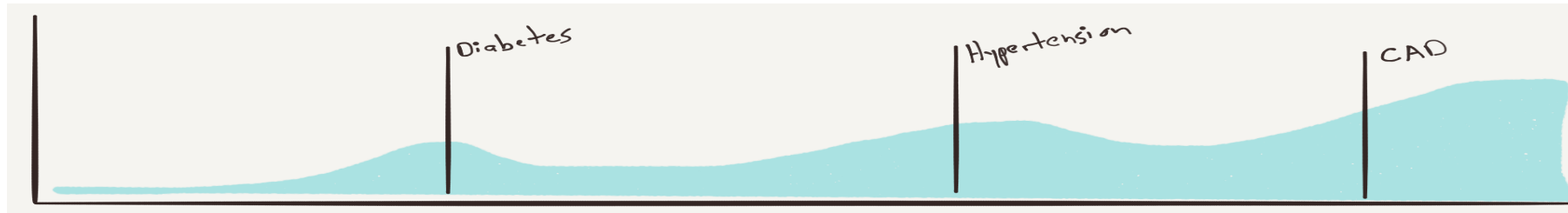
Cancer Case #1 Trajectory



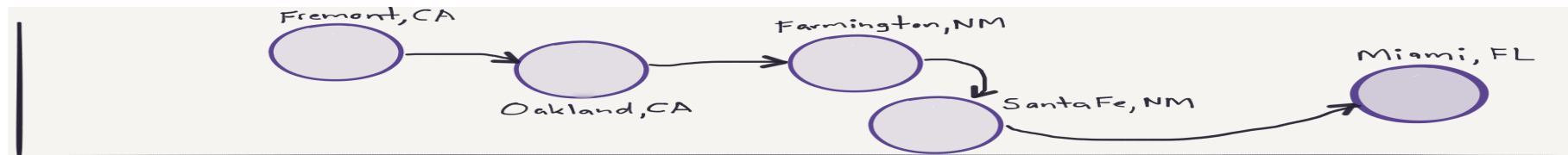
Cancer Case #2 Trajectory



Comorbidity Cofactor Trajectory



Residence / Geospatial Cofactor Trajectory



Patient's Lives are Complicated!

Patient doesn't know they are eligible for screening



Screen detected

Fear of screening
Fear of finding something

Is screening covered
How much does it cost

Don't have GP
Who do I schedule appointment with?
Work schedule



Incidental

First clinical presentation



Symptomatic

First symptom

Time off work
Childcare
Out of pocket cost
transportation

Lack of help navigating
No support
Getting Results

Dismissed
Multiple visits
Treatment for other illness



Diagnostic Tests



Specialists



Diagnostic Tests

LONG wait for results difficult

Multiple tests over many weeks and months

Anxiety, Confusion
What do I do next?

Try to understand diagnosis and what test results mean

Diagnosis

Traumatic
Am I going to die?
How do I tell my family?

Not part of treatment discussion

Barrier to receiving treatment
Barrier to receiving support and survivorship
Barrier to receiving end of life care

Don't have transportation to treatment

Not treating the whole person

Lack of support for caregivers

Insurance coverage
Lost wages
Cost of treatment
Cost of treating side effects

Disconnect in communication
Who's the point person?

Hospitalized for symptoms of disease and/or side effects

Progression or recurrence

Treatment and Survivorship

Adverse events
Complications
Severe Fatigue
Poor physical function

Not offered Palliative care

Support and resources not consistent

More time off work
Out of pocket cost

Symptomatic
More testing

Fear
Uncertainty
What's next?

Team not culturally aware and doesn't understand not all patients have food and housing security

End-of-Life care

Don't want to burden my family
Don't want to suffer

Never had advanced care planning conversation



Hospice
Other logistics

Pain Control
Need assistance

Fragmented system
Have to self advocate and navigate

Life Happens!

Caregiver for spouse
Other morbidities
New Job
Patient lives alone
Training for Marathon

Family Reunion
Child getting married
Trip planned out of country
Pay Bills
Take care of House

Look after grandchildren
Insurance doesn't cover everything
Moving
Sick child
Weekly social plans

Qualify for Clinical Trial – start process

THE BIG DATA SCIENTIST TRAINING ENHANCEMENT PROGRAM

Developing the Next Generation of Healthcare Data Scientists



Frank Meng, Program Co-Director (Frank.Meng2@va.gov)

Kelly Gaynor, Program Manager (Kelly.Gaynor@va.gov)

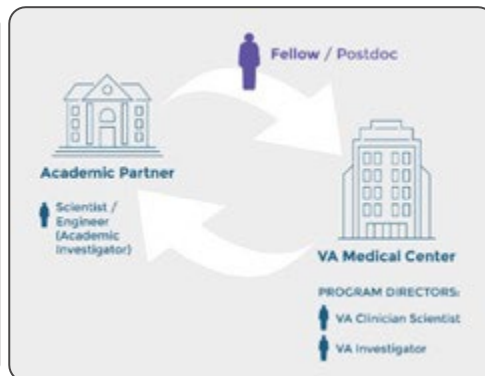
50 participants

12 current cohort



Research Projects

Since the launch of the program, BD-STEP fellows have initiated diverse studies using **VA health care data resources**. These including predicting hepatocellular carcinoma in hepatitis VA patients using a cohort of more than 180,000 Veterans, comparing frailty assessment via clinical teams and machine learning to predict mortality in patients with congestive heart failure, and characterizing dynamic biological changes associated with prostate cancer progression in obese patients.



Service Projects

In addition to each fellow's individual research project, funded fellows **spend 25% of their time on a Service Project that is of direct value and impact to the VA health care system** and/or the fellowship. Service projects will be selected by the BD-STEP Coordinating Center based on their significance and impact on identified program and health care system needs.

Questions?



Service to others is the rent you pay for
your room here on earth - Muhammad Ali



Thanks!

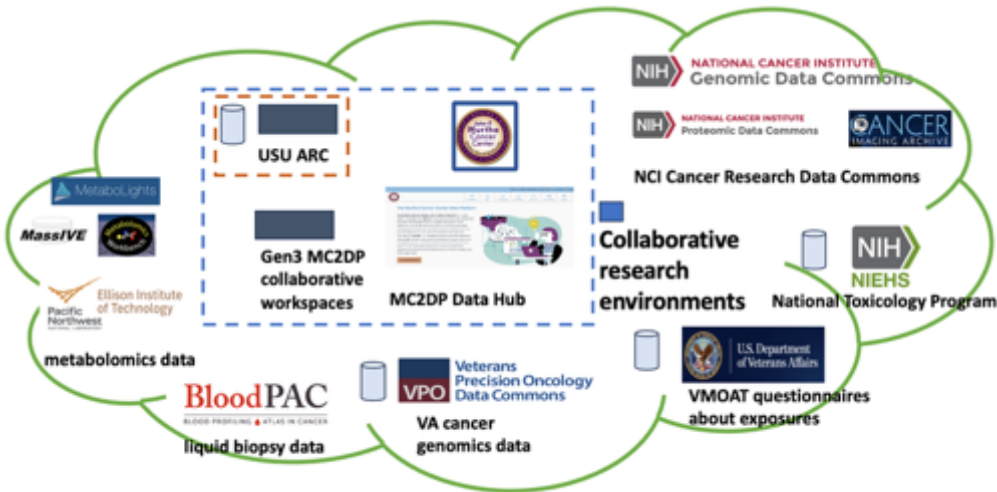
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 [@jleePSOC](#)

The Murtha Cancer Center Data Platform

The Murtha Cancer Center Data Platform (MC2DP) is a data mesh. The goal of the MC2DP is to discover and study advanced precision technologies that will enable prevention, early detection, and enhanced treatments of cancers potentially arising due to exposures to environmental contaminants and toxin hazards by military service members and veterans. The vision of MC2DP is to integrate federal scientific platforms with public-private innovators revealing the impact of service-related exposures to environmental contaminants and toxin hazards and developing prevention and early detection approaches and advanced treatments of cancers arising from these exposures.

DISCOVER DATA



Courtesy of Bob Grossman

Data sharing with public

<https://mc2dp.data-commons.org>

Data Connections

Updated: 10/13/2025

Source	Cohort / Study	Data Description	Connection Type	Connection Status	# Patients Available/Expected
GDC	APOLLO LUAD	Genomics	API	[Established - Real Data]	87/87
PDC	APOLLO LUAD	Proteomics	API	[Established - Real Data]	100/100
GDC	APOLLO OV	Genomics	API	[Established - Real Data Pending]	0/70
PDC	APOLLO OV	Proteomics	API	[Established - Real Data]	70/70
Windber	APOLLO 5	Clinical Metadata	API	[Synthetic Data]	56/56
Windber	APOLLO 5	Clinical Detailed	API	[Connection Pending]	0/56
Windber	PROMETHEUS 8A	Clinical Metadata	API	[Synthetic Data]	56/56
PNNL	PROMETHEUS 8A	Proteomics	CBDX*	[Synthetic Data]	144/144
Ellison	PROMETHEUS 8A	Metabolomics	CBDX*	[Data Pending]	
TCIA	APOLLO 5	Images	API	[Data Pending]	
TCIA	VA-REPOP	Images	API	[Established - Real Data]	32/812
VPODC	VA-REPOP	Longitudinal clinical, targeted sequencing	API	[Established - Real Data]	265/812
VPODC	VABio/ APOLLO 5/ Prometheus 8A	Longitudinal clinical, targeted sequencing	API	[Data Pending]	106/106

Murtha Research Network

The development of targeted cancer prevention and treatment interventions require access to the highest quality human biospecimens and data uniformly acquired, stored, and distributed under rigorous standard operating procedures and quality control standards. The Murtha Research Network develops, tests, and evaluates ways to increase effectiveness and efficiencies of integrated cancer support for the Military Health System.

