



MILITARY CANCER OUTCOMES RESEARCH (MilCan): LINKING MILITARY OCCUPATIONAL AND ENVIRONMENTAL EXPOSURES TO CANCER OUTCOMES IN THE MILLENNIUM COHORT STUDY

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NON-DISCLOSURE



- The authors have no conflicts to report.



BACKGROUND & RATIONALE



- U.S. service members and veterans experience **higher rates of certain cancers** than the general population
- Military service involves **unique occupational and deployment-related exposures**, including:
 - Aviation-related ultraviolet radiation
 - Chemical toxicants (e.g., PFAS)
 - Combustion by-products and deployment-related exposures
- Limited prior research has **integrated exposure history, clinical outcomes, and tumor pathology** at scale

PHASE 1-a – STUDY ON THE INCIDENCE OF CANCER DIAGNOSIS AND MORTALITY AMONG MILITARY AVIATORS AND AVIATION SUPPORT PERSONNEL



January 2023

The estimated cost of this report or study for the Department of Defense is approximately \$304,000 in Fiscal Years 2021 - 2022. This includes \$228,000 in expenses and \$76,000 in DoD labor.

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Rogin, A. (Host). (2023, Mar 25). Study finds higher cancer rates among U.S. military airmen and ground crews [Audio podcast]. PBS. <https://www.pbs.org/newshour/show/study-finds-higher-cancer-rates-among-u-s-military-airmen-and-ground-crews>



U.S. Navy photo by Benjamin C. Jernigan/Released



OBJECTIVE & HYPOTHESIS



Objective

The primary objective of the **Military Cancer Outcomes Research (MilCan) project** is to improve understanding of cancer risks, progression, and outcomes in U.S. service members and veterans by integrating clinical, exposure, and pathological data

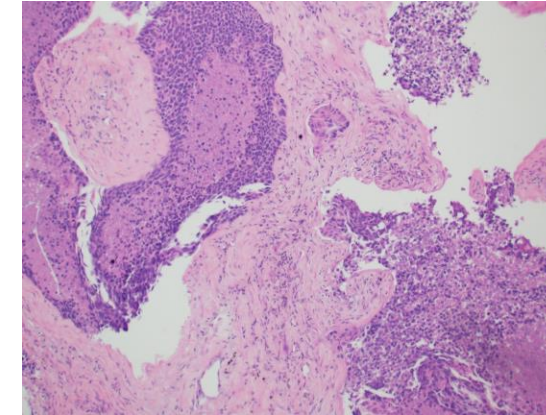


Photo courtesy of JPC

Hypothesis

Unique military occupational and deployment-related exposures are associated with cancer development, as well as distinct tumor biology and histologic phenotypes

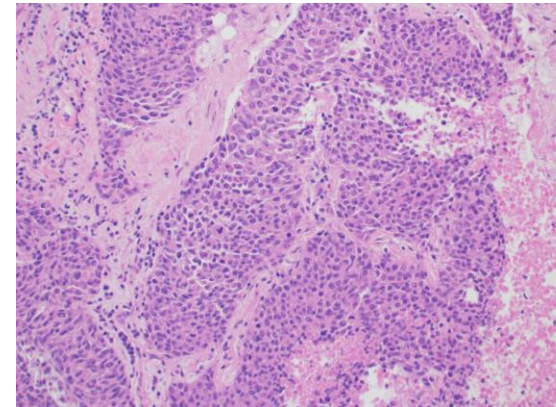


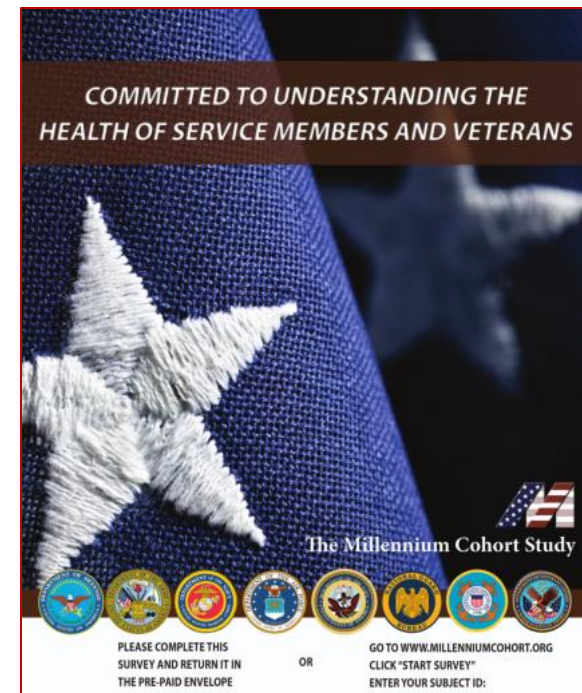
Photo courtesy of JPC



STUDY OVERVIEW



- ① Largest and longest running military cohort study
 - Initiated July 2001 (pre-9/11)
 - Planned follow-up through 2068
 - Linkages to DoD/VA and federal databases
- ① >260,000 military personnel enrolled between 2001-21
 - All service branches and components
 - Women and other underrepresented groups oversampled
 - 67% of participants have separated from service
- ① Research findings inform policy and programs





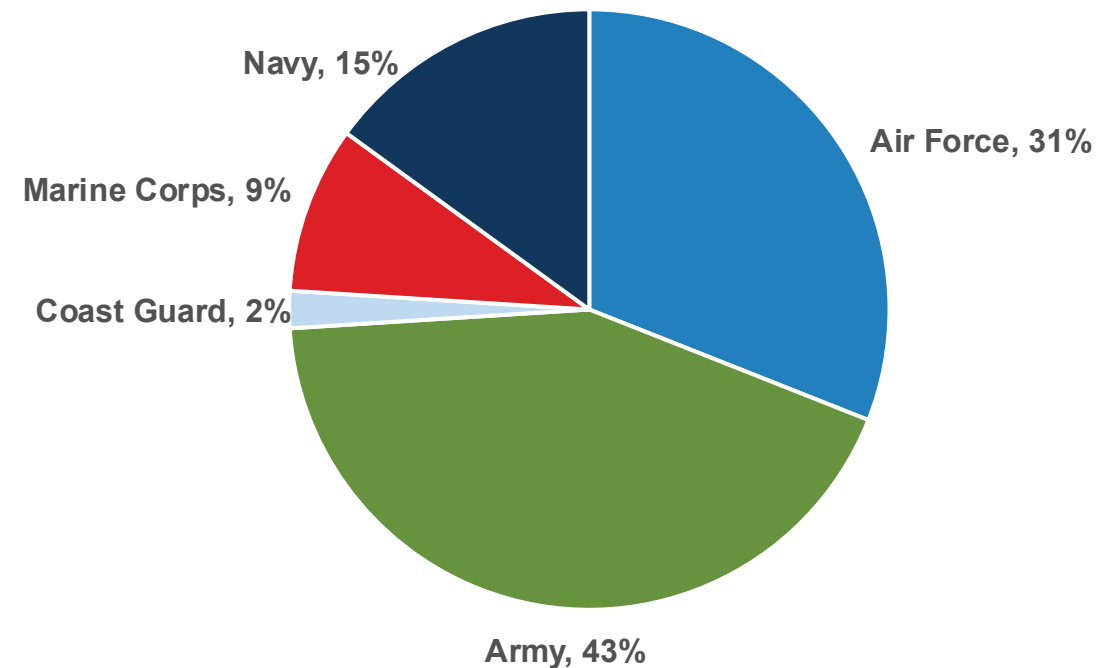
MILLENNIUM COHORT STUDY (MCS) PARTICIPANT PROFILE (N = 260,228)



Panel (enrollment year)	Mean current age (SD)
1 (2001)	59 (9)
2 (2004)	47 (5)
3 (2007)	44 (4)
4 (2011)	42 (5)
5 (2020)	32 (5)
All	46 (12)

Baseline characteristics	%
Female	31
Racial or ethnic minority	31
Enlisted	82
Active component	70
Current status*	%
Ever deployed	61
Separated	67
Deceased	2

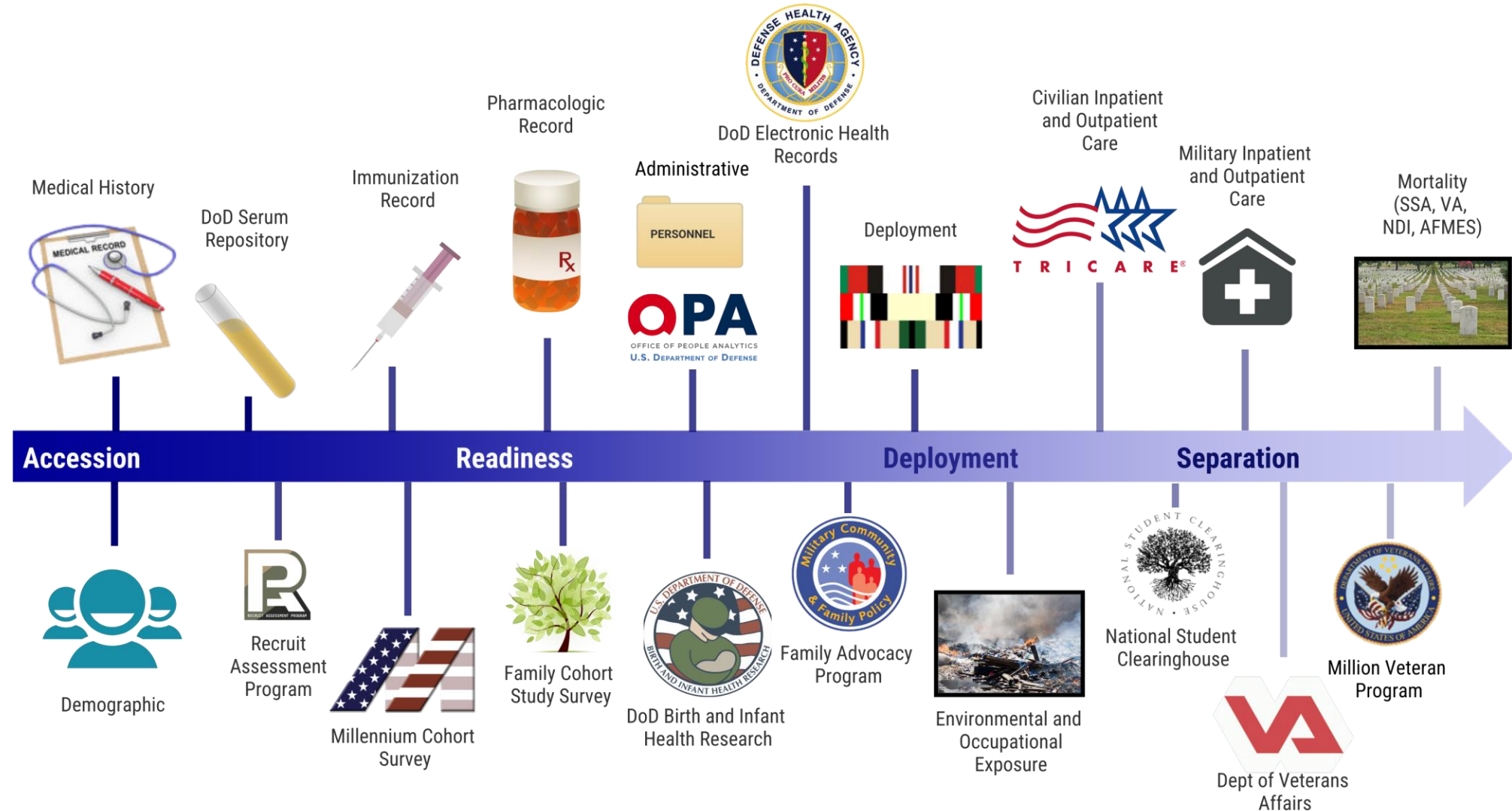
*Data as of 2023



Note: Air Force includes Space Force members.



EXISTING DATA LINKAGES





ACTIVE OR PLANNED LINKAGES



Individual Longitudinal Exposure Record (ILER)

Individual-level occupational and environmental exposures



Joint Pathology Center (JPC)

World's largest pathology archive with digital pathology and biospecimens



Department of Defense Cancer Registry (DoDCR)

Centralized cancer ascertainment in the Military Health System (MHS)

Virtual Pooled Registry Cancer Linkage System (VPR-CLS)

Nationwide cancer registry linkage for complete case ascertainment



Linkages enable **validated cancer outcomes** and **exposure-informed analyses**



DATA INTEGRATION



Building the military cancer data warehouse

Integrates:

- MCS survey data
- Electronic health records
- Environmental & occupational exposure data
- Tumor pathology, biospecimens, & imaging

Enables **exposure-informed, pathology-linked cancer epidemiology** at cohort scale

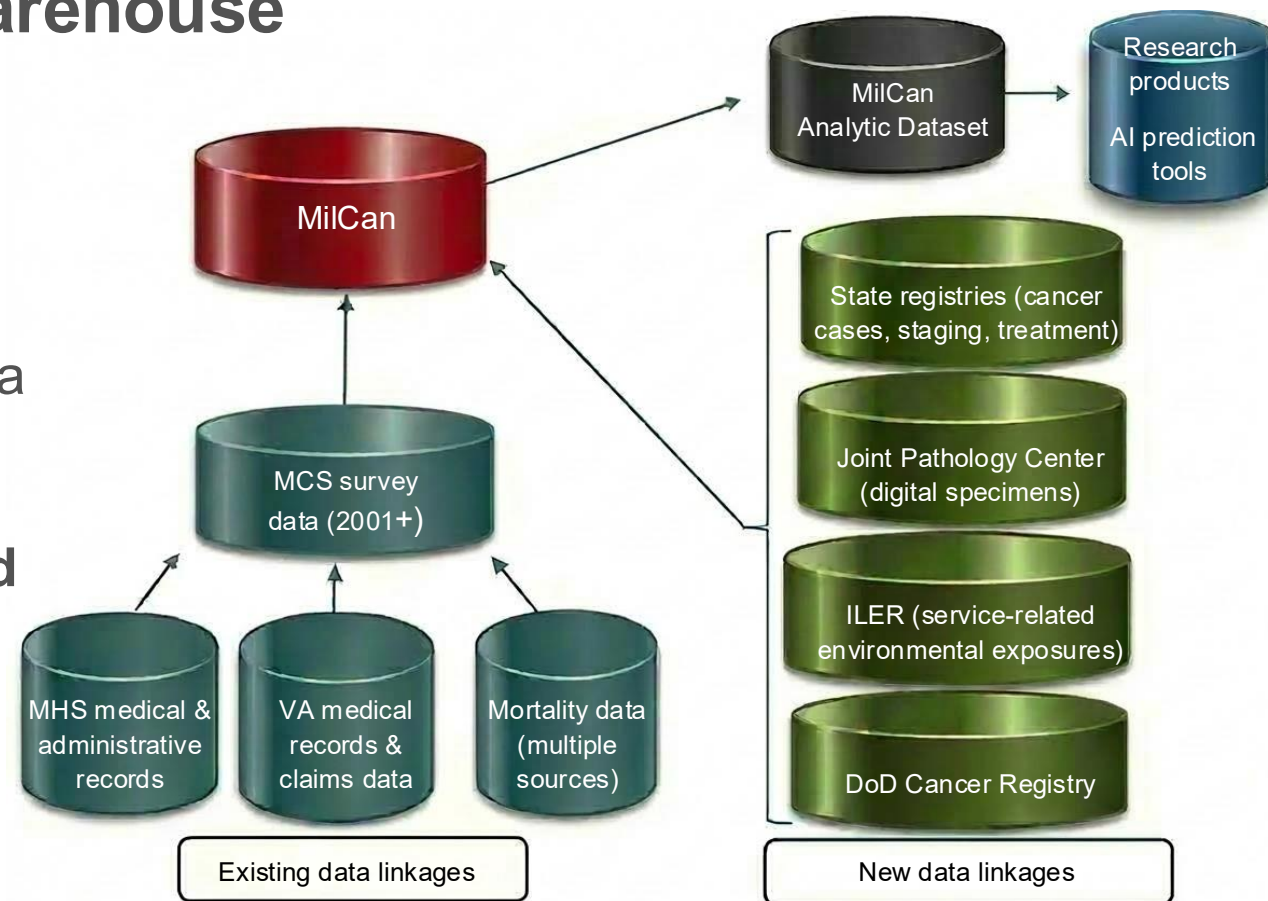


Figure refined using GenAI.mil



PRELIMINARY FINDINGS



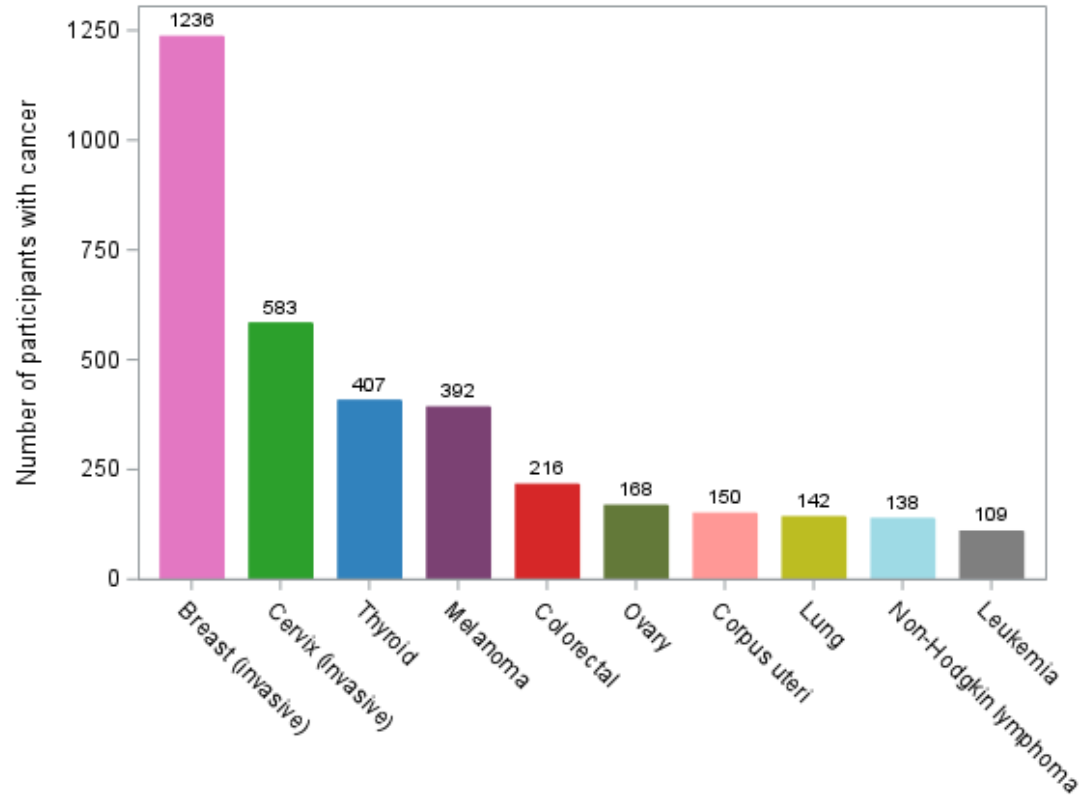
- **~12,000 cancer occurrences** identified in MCS survey (through 2019-2021) and military/VA medical records (through 2023)
- **~10,000 specimens** in JPC matched to MCS participants
 - Completed digitization of 3,874 cancer specimens
- **~9,250 preliminary cancer matches** were identified through the VPR-CLS across 43 state registries (data up to 2022)



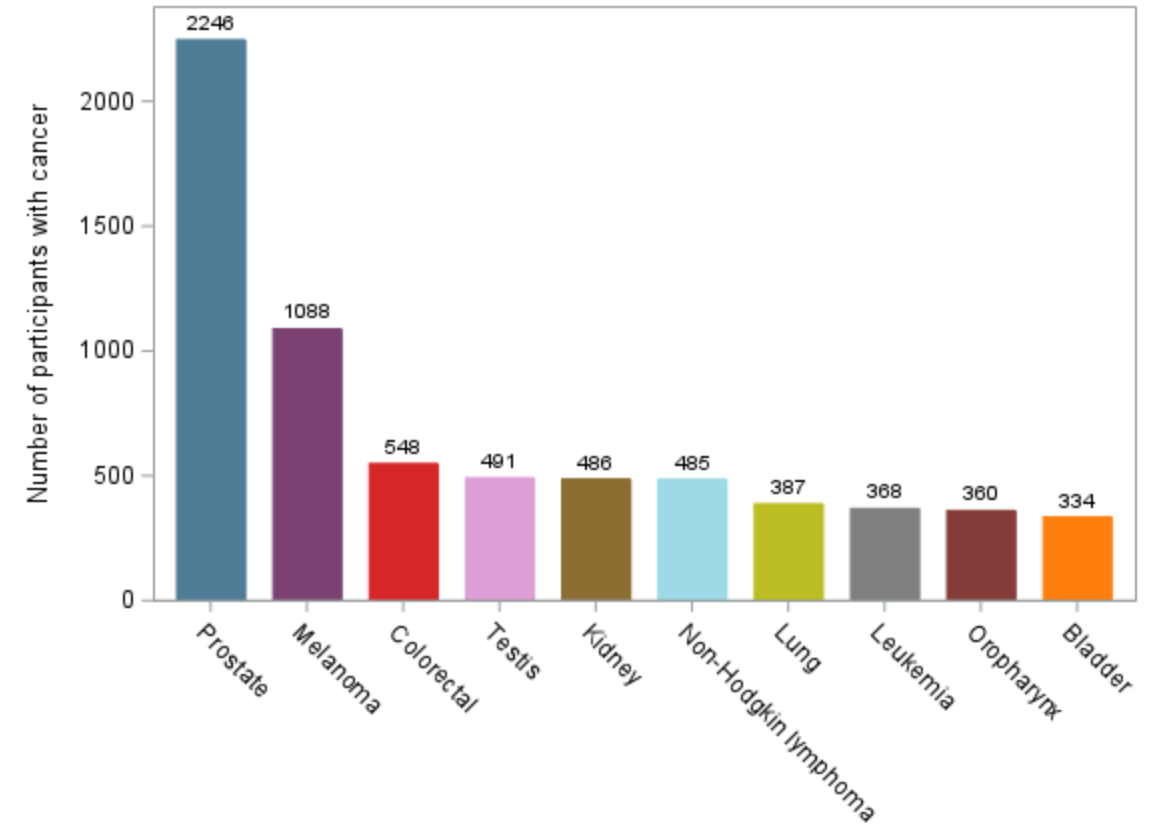
PRELIMINARY FINDINGS

Most common cancers in MCS by sex

a. Women



b. Men





CONCLUSIONS



Implications for Force Health Protection and Cancer Prevention

- MilCan enables **population-based analyses** of:
 - *Military occupational exposures*
 - *Environmental and behavioral risk factors*
 - *Cancer incidence, histologic features, tumor characteristics, and outcomes*
- **Provides infrastructure to:**
 - *Identify high-risk military subpopulations*
 - *Consider distinct disease histologies and biologies relative to exposures*
 - *Inform **exposure mitigation and prevention policies***
 - *Support **force health protection and medical readiness***
- Establishes a scalable platform for **precision cancer epidemiology** in post-9/11 service members and veterans

MilCan bridges exposure history, clinical data, and pathology to advance cancer prevention and readiness across the military life cycle



PARTNERS/COLLABORATORS



The
Joint Pathology
Center

Joint Pathology Center



Individual Longitudinal Exposure Record



Virtual Pooled Registry



USU Murtha Cancer Center
Research Program

USU Murtha Cancer Center



QUESTIONS?



2023 Outstanding Research Accomplishment | TEAM/MILITARY



Millennium Cohort Program Team

Rudolph P. Rull, Ph.D., MPH
Team Lead

August 14-17, 2023 | Kissimmee, FL | Gaylord Palms Resort & Convention Center

MEDICAL READINESS for the Future Fight

Photo courtesy of MHSRS



For inquiries about collaboration, please contact:

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EXTRA SLIDES





STUDY ORIGIN



- ① National Defense Authorization Act for Fiscal Year 1999
 - Sect. 743: Establish “a longitudinal study to evaluate data on the health conditions of military personnel returning from deployment in a military operation to ensure the rapid identification of any trends in diseases, illnesses, or injuries among such personnel as a result of such operations.”
- ① Naval Health Research Center designated as the DoD Center for Deployment Health Research





MILLENNIUM COHORT STUDY

ENROLLMENT (N = 260,228)

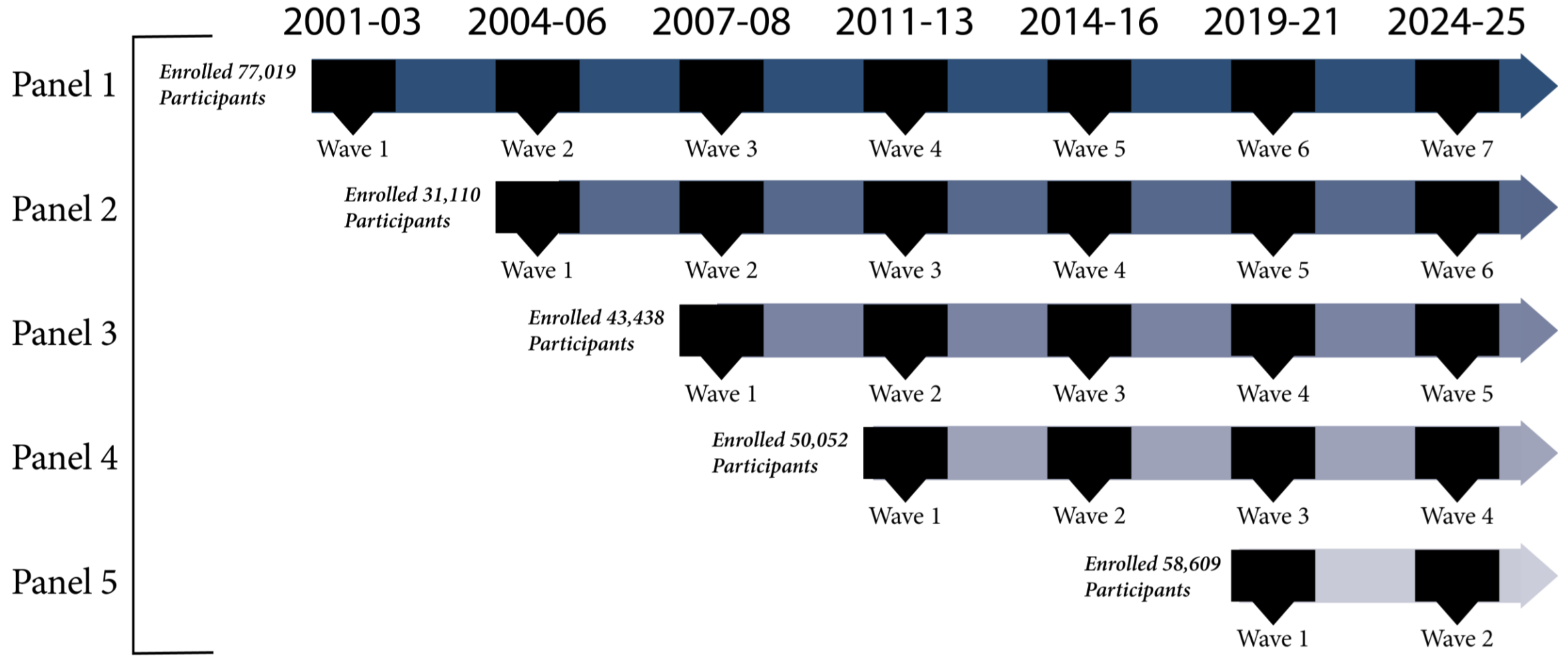


Panel	Enrollment dates	Years of service at enrollment	Oversampled groups	Roster size (date)	Total contacted	Total enrolled (%)
1	Jul 2001–Jun 2003	Unrestricted	Women Reserves/Guard Prior deployers*	256,400 (Oct 2000)	214,388	77,019 (36%)
2	Jun 2004–Feb 2006	1–2	Women Marine Corps	150,000 (Oct 2003)	123,001	31,110 (25%)
3	Jun 2007–Dec 2008	1–3	Women Marine Corps	200,000 (Oct 2006)	154,270	43,438 (28%)
4	Apr 2011–Apr 2013	2–5	Women Married	250,000 (Oct 2010)	247,266	50,052 (20%)
5	Sep 2020–Jun 2021	1–5	Women Married	500,000 (Jun 2020)	360,741	58,609 (16%)

*Deployment to Southwest Asia, Bosnia, and/or Kosovo after August 1997



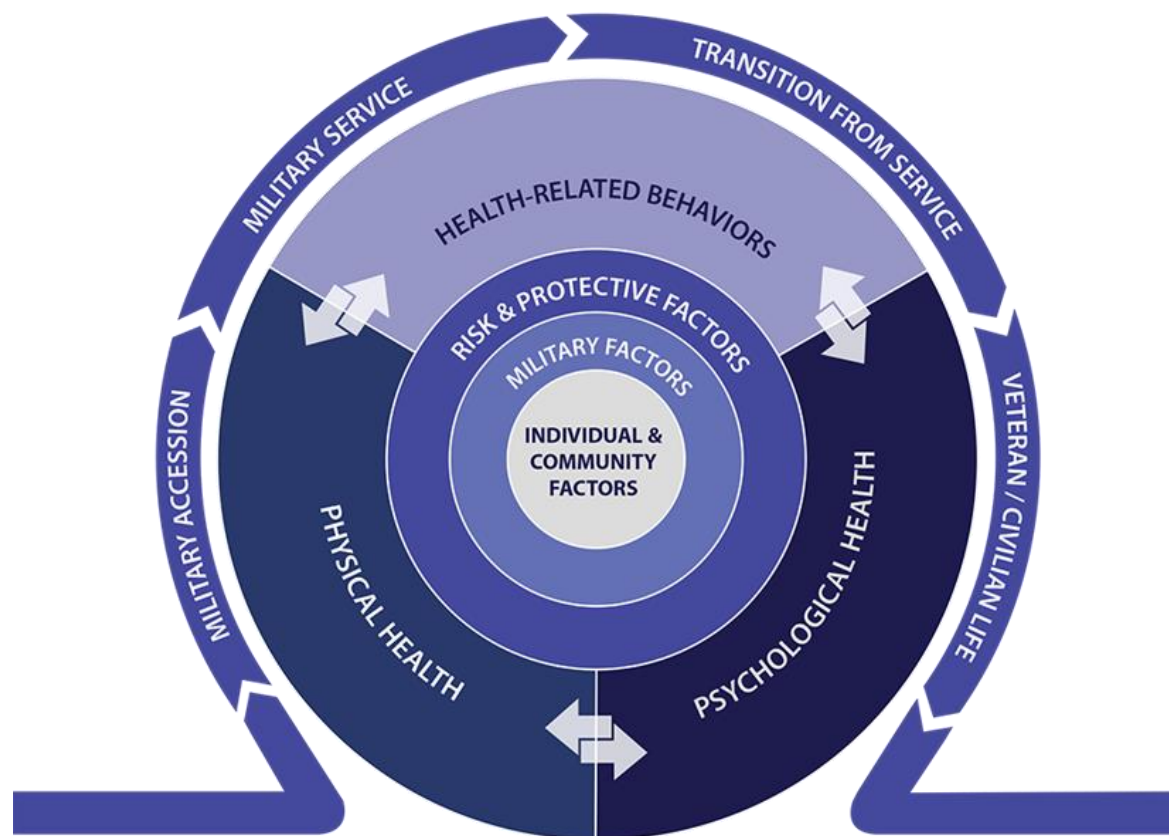
MULTI-PANEL DESIGN



Next enrollment panel (#6): 2027-28



CONCEPTUAL MODEL



Key Features

- ① Military life-course perspective of influences on long-term health and well-being
- ① Environmental exposures
- ① Intersection of physical and mental health



MORTALITY IN THE MILLENNIUM COHORT STUDY



Ⓜ Key findings from recent work:

- Recent deployment was protective for all-cause mortality¹ and cancer mortality² among OEF/OIF/OND service members and veterans over a 20-year period, as well as for all-cause mortality among 1990–1991 Gulf War era and Veteran personnel specifically³
 - *Risk factors for mortality included combat exposure,¹ enlisted rank,^{1,2} and health factors (e.g., stressful life events, smoking, alcohol use)^{1,3}*

1. Carey et al. All-cause mortality among United States military personnel: Findings from the Millennium Cohort Study, 2001-2021. *Ann Epidemiol.* 2024;99:1-8. doi:10.1016/j.annepidem.2024.08.006
2. Sharifian et al. Risk and protective factors for cancer mortality among United States service members and veterans (2001-2018). *Cancer Epidemiol Biomarkers Prev.* 2023;32(5):606-616. doi:10.1158/1055-9965.EPI-22-0943
3. Carey et al. All-cause mortality and 1990-1991 Gulf War service within the Millennium Cohort Study (2001-2021). *Am J Epidemiol.* 2025;194(10):2765-2774. doi:10.1093/aje/kwae442