Study on the Incidence and Prevalence of Malignant Cancers Among U.S. Special Operations Forces

Produced by the
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1. Executive Summary

On 27 September 2023, the Commander, U.S. Special Operations Command (SOCOM) requested support through the Assistant Secretary of Defense for Health Affairs. The request was for a new public health assessment of cancer incidence among the SOCOM population. To support this request, the Armed Forces Health Surveillance Division (AFHSD) conducted an epidemiologic study to evaluate the incidence and prevalence of malignant cancers among Special Operation Forces (SOF) and determine if it was greater than the non-SOF general U.S. military population. The study utilized data from the Defense Medical Surveillance System (DMSS), DoD Cancer Registry (DoD CR), Veteran's Affairs (VA) Corporate Data Warehouse (CDW), and the VA Central Cancer Registry (VACCR) to identify cancer cases. The denominator population consisted of a total of 231,733 SOF and 5,154,301 non-SOF personnel from January 2001 to December 2023. The cancer surveillance window was January 2001 through December 2024. All malignant cancers combined (any cancer), and 14 specific cancer types were investigated. The incidence rates of any cancer, melanoma of the skin, and testicular cancer were statistically significantly higher among the SOF cohort compared to the non-SOF cohort with adjusted incidence rate ratios (aIRR) and 95% confidence intervals (CI) of 1.18 (1.12-1.23), 1.33 (1.15-1.53), and 1.21 (1.08-1.35), respectively. Incidence rates of all other cancer types were lower or similar among the SOF cohort compared to the non-SOF cohorts. No significant differences in cancer incidence rates comparing SOF operators to enablers were found. Median age at diagnosis was statistically lower for prostate cancer cases (8 years younger) and mean age for lung and bronchus cancer diagnosis was 3.6 years lower among the SOF cases compared to the non-SOF cases. Overall and cancer specific mortality rates were lower among the SOF cohort compared to the non-SOF cohort. These results indicate a higher risk of incident all type malignant cancers and some type-specific cancers among SOF personnel compared to the non-SOF general military population. Continued surveillance of these populations, as they age, may yield additional significant findings. Further investigation into the potential exposures and risk factors associated with service in SOF may be warranted.

2. Purpose

The AFHSD of the Defense Health Agency (DHA) was requested to conduct an epidemiologic analysis of cancer among the SOCOM population (Appendix B). The specific questions requested from SOCOM were:

1. Are there are significant or distinct differences in SOF and non-SOF cancer diagnoses within the DoD? Compared to civilian populations? (e.g., incidence, types, rarity, complexity, age of onset, or severity, etc.)
2. Are there distinct differences in assessed and selected SOF personnel and SOF support personnel?
3. Are there identifiable trends, characteristics, exposures, or other factors among the SOF population that contribute to cancer risk?
4. Is the military health system able to detect early cancer and provide holistic, integrated cancer care commensurate with national averages and treatment outcomes? prospectively for examination of future health-related concerns.

AFHSD had data available to respond to questions 1 and 2 as part of Phase 1 of the study, except for comparisons to the civilian population. Acquiring data to compare to civilian populations would have added up to 2 additional years to complete the study. Questions 3 and 4 will also require additional data and resources outside the scope of AFHSD and are not a part of this report.

3. Background

Multiple studies have investigated the incidence of cancer among U.S. service members.[1-9] However, there are relatively few publications on the risk of cancer among the Special Operation Forces (SOF) population. Only one published case report on testicular cancer of a special operator could be found.[10] An internal public health assessment of the risk of cancer among SOF was conducted by the AFHSD and released to SOCOM in 2016. This study found an increased risk of bladder cancer among special operators; however, the numbers were small. Additionally, this study was limited by several methodological issues, such as the accuracy of the algorithm to identify SOF members, follow-up time for cancers was limited to time in active service, and comparisons were only made to non-SOF deployers. The Special Operations population is a unique force exposed to complex environments on land, seas, and air, and they may have different risks of cancer than the general U.S. military population. They may face increased exposure to potential carcinogens and risk factors, such as increased lead exposure from firing ranges, use of automotive fuels, and production of ammunition, oxidative stress, and other environmental exposures in unique and austere conditions.[11-13]

According to contacts within SOCOM, since the last assessment in 2016, the perceived impact of cancer among the SOF population has intensified. Therefore, U.S. SOCOM requested additional support from AFHSD to conduct a new public health assessment of the impacts of cancer in the SOF population. AFHSD, in coordination with SOCOM and Veteran's Affairs (VA), conducted this new assessment of cancer risk among SOF personnel and the results of which are presented in this report. This new assessment improves upon limitations of the 2016 assessment by using a verified algorithm to identify SOF members, expanding the surveillance time period to include cancer after leaving service, and utilizing the DoD cancer registry (DoD CR), and the VA Central Cancer Registry (VACCR).

The objectives addressed in this report are to:

1. Determine the incidence and prevalence of malignant cancers and type-specific cancers among the SOF population and compare those rates to the cancer rates among:
    a. All non-SOF conventional/general purpose forces
    b. All non-SOF conventional/general purpose forces with at least one deployment
2. Determine if there are differences in the incidence and prevalence of malignant cancers and type-specific cancers between the assessed and selected SOF specialties (operators) compared to enabler specialties within the SOF population.
3. Determine the incidence of death due to cancer among the SOF population compared to the two conventional/general purpose forces cohorts.
4. Characterize the cancer cases within the SOF population including types of cancer and age at diagnosis.

4. Methods

4.1 Study Design and Data Sources

A retrospective cohort analysis was conducted to determine the incidence and prevalence of cancer among SOF between January 1, 2001 and December 31, 2024. SOF rates were compared to the cancer rates among the non-SOF general U.S. military population and a deployed subset of that population.

Personnel, demographic, military service, and medical diagnostic International Classification of Diseases (ICD) 9th and 10th revision encounter data were obtained from the Defense Medical Surveillance System (DMSS). Additional medical encounter data were obtained from the VA Corporate Data Warehouse (CDW). Confirmed cancer cases were obtained from the DoD CR and the VACCR. Additional cancer cases were identified using the medical encounters data (DMSS and VA CDW). DoD CR and VACCR primarily include cases identified in military and VA treatment facilities. DMSS and VA CDW health care encounter data were included to improve capture of cancer cases diagnosed in outsourced or community care settings. This is especially important for ascertaining cases among reserve and guard members and for service members after they retire or leave military service.

National Death Index (NDI) data were provided by the Defense Suicide Prevention Office (DSPO). The NDI is a central repository for deaths occurring in the U.S. since January 1979. At the time of the request, death records were available through the end of 2022. The data provided included all deaths, regardless of cause, among the study population. The underlying cause of death variable (ICD-9 and ICD-10 codes) was used to identify deaths due specific cancer types.

4.2 Study Populations

The SOCOM Data Office generated a roster of SOF personnel during the study period and provided it to AFHSD. After a quality control check of the roster with a separate source of data on SOF personnel, it was determined that the roster was incomplete, especially for earlier years of the study period. Therefore, personnel data in DMSS was queried to identify additional SOF personnel based on having a SOCOM major command code at any time during the study period (Appendix C) The SOF roster and DMSS identified SOF personnel were combined to form the SOF cohort. Individuals in the SOF cohort were then categorized as operators or enablers using their occupational specialty codes and categorization by SOCOM. If a SOF member ever had an occupational specialty for an operator, they were considered an operator for the analysis. Enablers were SOF members who never had an operator occupational specialty code.

The SOF cohort was compared to two non-SOF cohorts. The first non-SOF cohort included all conventional/general purpose forces in service at any time during the study period. The second cohort was a subset of the first. It included all conventional/general purpose forces who had at least one deployment (greater than 30 days in length) during their military career. It was expected that most SOF personnel had at least one deployment, therefore this subset of the original cohort was used to make the populations more equivalent in terms of underlying health (healthy deployer effect) and general deployment exposures.

Individuals from any of the cohorts were excluded from a specific cancer type analysis if they had a diagnosis of that cancer type prior to entering the study cohort.

4.3 Cancer Cases

All malignant cancer diagnoses were included in the study (any cancer) and described among the SOF cohort. Fourteen specific cancers were analyzed separately for all cohorts, including cancer of the bones and joints, brain and other nervous system, breast (female), colon and rectum, kidney and renal pelvis, leukemia, lung and bronchus, melanoma of the skin, non-Hodgkin lymphoma, pancreas, prostate, testis, thyroid, and urinary bladder. These 14 cancers were selected based on the most common cancers, concern from advocacy groups, and prior cancer studies that demonstrated increased incidence in military populations.

Cancer cases from DoD CR and VACCR utilized ICD-O-3 codes and were categorized according to SEER site recoding instructions.[14] All encounter-defined cancer cases were defined by ICD-9 and ICD-10 codes (Appendix D) using the AFHSD standard case definitions.[15] These case definitions are actively updated to provide the most accurate definitions for case ascertainment. The current encounter-based cancer case definition requires (1) one hospitalization with a cancer diagnostic code in the first diagnostic position; OR (2) one hospitalization with a V- or Z-code indicating a radiotherapy, chemotherapy, or immunotherapy treatment procedure (ICD-9-CM: V58.0, V58.1, V58.11, V58.12; ICD-10-CM: Z51.0, Z51.1, Z51.11, Z51.12) in the primary diagnostic position AND a cancer diagnostic code in the second diagnostic position; OR (3) three or more outpatient medical encounters, occurring within a 90-day period, with a cancer diagnostic codes in the primary or secondary diagnostic position. Diagnostic positions and procedure codes were not present in the VA CDW data, therefore a modified case definition was applied for those encounters requiring (1) one hospitalization with a cancer diagnosis; OR (2) three or more outpatient medical encounters, occurring within a 90-day period, with a cancer diagnosis.

4.4. Analysis

Descriptive statistics, incidence rates, prevalence rates, and mortality rates were generated for each cohort for any cancer and for the 14 specific cancers. For cancer cases, the minimum, maximum, mean, and median age at diagnosis was calculated. Mean age was compared between cohorts using a Satterthwaite t-test. Median age was compared between cohorts using a non-parametric median test. In addition, a descriptive analysis of all first occurring cancer types was conducted among the SOF cohort.

4.4.1. Incidence Analysis

For the incidence analysis, to remove period and cohort effects, differences in the ages of the SOF and comparison cohorts, and to prevent bias due to missing data in prior years, subjects were required to start military service during the study period, 2001-2023. Person-time follow-up began at entry into the military. Person-time was censored on December 31, 2024, last documented medical encounter in the DMSS or VA CDW, or at the incident cancer diagnosis date, whichever came first.

For the any cancer outcome, the earliest onset date or medical encounter of any type of cancer was defined as the incident cancer date. For type-specific cancer outcomes, the earliest onset date or medical encounter for the specific cancer of interest was defined as the incident cancer date for that cancer type. For the type-specific cancer analyses, an individual may have a different cancer type diagnosed prior to being diagnosed for the cancer type of interest and therefore may be counted as a case for multiple qualifying cancer types.

Incidence rates (IR) per 100,000 person-years (py) and 95% confidence intervals (CI) were calculated for each cancer outcome and cohort. Crude and adjusted incidence rate ratios (IRR) comparing the SOF cohort to the comparison cohorts and SOF operators versus enablers were conducted using Poisson regression models. To account for the varying lengths of time in service between subjects, the natural logarithm of person-time was included as an offset in the models. IRR models were adjusted for age, sex, race-ethnicity, and component.

4.4.2. Prevalence Analysis

Annual prevalent cases were defined as having a qualifying cancer case incident diagnosis occurring during or any time prior to the year of interest. Individuals were counted in the denominator if they were still being followed any point during the year of interest. Annual prevalence was calculated for each cohort for the overall malignant cancer outcome and type-specific cancers. Prevalence estimates for 2024 are presented in this report.

4.4.3. Mortality Analysis

For the mortality analysis, the person-time denominator was extended through the end of the NDI data availability, December 31, 2022, or the date of death, whichever came first. Counts and crude mortality rates per 100,000 person-years were calculated for any death, any cancer death, and for each of the 14 type-specific cancer deaths.

4.4.4. Sensitivity Analyses

Three different sensitivity analyses were conducted.

The first applied a 10-year latency period for all cancer outcomes. This was conducted to account for latency, the time between exposure to a cancer-causing agent and the development of a cancer.[16,17] For this sensitivity analysis, cancers and person-time for the first 10 years of a subject's time in the study were excluded from the analysis. Inherently, individuals who were followed for less than 10 years in the primary analysis, were excluded from this sensitivity analysis.

The second sensitivity analysis restricted the study cohorts to active component service members only. This was done to account for the differential capture of medical events due to reserve and guard component members not being eligible for TRICARE when not activated.

The third sensitivity analysis was performed to remove the requirement that service members started service on or after January 1, 2001. This sensitivity analysis included all service members who were in service at any time between January 01, 2001 and December 31, 2023, regardless of when they started military service.

All analyses were conducted using SAS-Enterprise Guide (version 8.3).

5. Results

5.1. Demographics

The study population consisted of 231,733 SOF members and 5,154,301 non-SOF service members, with 1,613,934 of those in the deployed non-SOF cohort. The SOF cohort had a higher percentage of several demographics when compared to the non-SOF cohort: males (89.6% versus 80.0%), non-Hispanic white (67.4% versus 59.1%), Air Force (25.4% versus 16.8%), officers (21.4% versus 8.2%), and active component (93.5 % versus 70.3%) service members (Table 1). Demographics of the SOF cohort were more comparable to the deployed non-SOF cohort for sex, race and ethnicity, and component.

Since all individuals in the study were required to start military service during the study period, most individuals in each cohort were 24 years of age and under when they entered the cohort. Year of entry varied by cohort with the majority of the SOF and non-SOF cohorts entering between 2010-2019 (45.9% and 43.3%, respectively), however, the majority of the non-SOF deployed cohort entered between 2001-2009 (69.7%) (Table 1). The length of follow-up differed between the cohorts with a median follow-up of 11.6 years for the SOF cohort, 7.3 years for the non-SOF cohort, and 15.1 years for the deployed, non-SOF cohort (Table 1).

Table 1. Characteristics of Study Cohorts: 2001-2023

	SOF Cohort		Non-SOF Cohort		Non-SOF Deployed Cohort	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**
Total individuals	231,733	100.0	5,154,301	100.0	1,613,934	100.0
Sex						
Male	207,579	89.6	4,123,051	80.0	1,395,542	86.5
Female	24,154	10.4	1,031,250	20.0	218,392	13.5
Age at entry into cohort (years)						
< 20	102,095	44.1	2,781,957	54.0	866,206	53.7
20-24	102,254	44.1	1,763,760	34.2	589,332	36.5
25-29	22,592	9.8	410,829	8.0	112,992	7.0
30-34	3,990	1.7	135,853	2.6	31,086	1.9
35-39	652	0.3	43,284	0.8	9,109	0.6
40-44	119	0.1	12,426	0.2	3,537	0.2
45-49	19	0.0	4,210	0.1	1,195	0.1
50-54	8	0.0	1,247	0.0	340	0.0
55-59	4	0.0	483	0.0	114	0.0
60-64	0	0.0	148	0.0	23	0.0
65+	0	0.0	104	0.0	0	0.0
Race/ethnicity						
Non-Hispanic, White	156,271	67.4	3,043,842	59.1	1,020,557	63.2
Non-Hispanic, Black	24,295	10.5	821,188	15.9	219,990	13.6

Hispanic	30,336	13.1	767,117	14.9	216,293	13.4
Non-Hispanic Other	20,831	9.0	522,154	10.1	157,094	9.7
Service at entry into cohort						
Army	122,062	52.7	2,509,457	48.7	705,402	43.7
Navy	10,319	4.5	970,918	18.8	322,757	20.0
Air Force	58,929	25.4	868,177	16.8	308,002	19.1
Marine Corps	40,335	17.4	804,240	15.6	277,500	17.2
Coast Guard	88	0.0	1,509	0.0	273	0.0
Service at exit from cohort						
Army	125,748	54.3	2,536,636	49.2	721,067	44.7
Navy	9,592	4.1	963,720	18.7	317,728	19.7
Air Force	59,011	25.5	881,544	17.1	312,490	19.4
Marine Corps	37,256	16.1	769,511	14.9	262,215	16.3
Coast Guard	126	0.1	2,890	0.1	434	0.0
Component at entry into cohort						
Active	216,572	93.5	3,625,515	70.3	1,330,107	82.4
Reserve	7,372	3.2	628,021	12.2	111,088	6.9
Guard	7,789	3.4	900,765	17.5	172,739	10.7
Grade at entry into cohort						
Enlisted	212,178	91.6	4,908,711	95.2	1,525,851	94.5
Officer	19,555	8.4	245,590	4.8	88,083	5.5
Grade at exit from cohort						
Enlisted	182,114	78.6	4,732,085	91.8	1,459,506	90.4
Officer	49,619	21.4	422,216	8.2	154,428	9.6
Year of entry into military service						
2001-2009	100,196	43.2	2,155,074	41.8	1,124,121	69.7
2010-2019	106,399	45.9	2,230,430	43.3	469,315	29.1
2020-2023	25,138	10.9	768,797	14.9	20,498	1.3
Occupation at exit from cohort						
Infantry/artillery/combat engineering	60,868	26.3	741,469	14.4	303,174	18.8
Armor/motor transport	3,775	1.6	262,335	5.1	88,935	5.5
Pilot/aircrew	10,648	4.6	82,626	1.6	40,603	2.5
Repair/engineering	44,893	19.4	1,350,266	26.2	486,244	30.1
Comm/intel	59,044	25.5	1,031,669	20.0	340,596	21.1
Healthcare	8,906	3.8	367,335	7.1	88,137	5.5
Other	43,599	18.8	1,318,601	25.6	266,245	16.5
Length of follow-up (years)						
<5	39,108	16.9	1,833,120	35.6	127,012	7.9
5-9	58,559	25.3	1,309,373	25.4	305,701	18.9

10-14	54,242	23.4	822,394	16.0	355,804	22.1
15-10	47,753	20.6	721,911	14.0	488,686	30.3
20+	32,071	13.8	467,503	9.1	336,731	20.9
Type of SOF member						
Operator	151,551	65.4	-	-	-	-
Enabler	80,182	34.6	-	-	-	-
Follow-up (Years)						
Minimum		0.02		0.01		0.01
Maximum		24.0		24.0		24.0
Mean		11.9		9.0		14.3
Median		11.6		7.3		15.1
Abbreviations: SOF, Special Operation Forces; N, number; %, percentage.						

5.2. Incidence of Cancer Cases

During the surveillance period, there were 2,105 cases of any cancer among the SOF cohort, resulting in a crude IR of 76.51 cases per 100,000 py (Table 2). Among the 14-type specific cancers evaluated, testicular cancer, melanoma of the skin, and thyroid cancer had the highest number of incident cases with counts of 345, 210, and 154 cases, respectively. However, female breast cancer, testicular cancer, and melanoma of the skin had the highest crude IR (23.63, 13.95, and 7.60 per 100,000 py, respectively).

Among the non-SOF cohort, there were 30,191 cases of any cancer (16,183 of which were among the deployed subset of this cohort), resulting in an IR of 65.31 cases per 100,000 py (Table 2). Similar to the SOF cohort, the highest cancer case count among the non-SOF cohort was for testicular cancer (n=3,975); however, the second largest number of cases was for thyroid cancer (n=2,913), followed by melanoma of the skin (n=2,385). As with the SOF cohort, the highest crude IR for the non-SOF cohort was for female breast cancer (IR=23.92 per 100,000 py) followed by testicular cancer (IR=10.69 per 100,000 py). However, for the non-SOF cohort, thyroid cancer had the third highest crude IR at 6.28 per 100,000 py. The non-SOF deployed cohort has similar trends in crude IR as the non-SOF cohort (data not shown).

5.3. Age at Cancer Diagnosis

Mean and median age at cancer diagnosis for the SOF cases was similar or older than the comparison cohort cases for most of the cancer types (Table 3). The median age of diagnosis for brain and other nervous system cancer, thyroid cancer, non-Hodgkin lymphoma, and leukemia, was statistically higher among the SOF cases compared to the non-SOF cases, but the median age difference was only 1-2 years.

In contrast, mean age of prostate cancer diagnosis among the SOF cases, 44.8 years, was 6 years younger than the non-SOF cases (mean age: 51.0 years; p-value <0.001) and the non-SOF deployed cases (mean age: 50.2 years; p-value <0.01). The median age of prostate cancer diagnosis among the SOF cohort, 44 years, was 8 years younger than the non-SOF cohort (median age: 52 years; p-value <0.001), and 7 years younger than the non-SOF deployed cohort (median age: 51 years; p-value <0.001). Additionally, the mean age of lung and bronchus cancer diagnosis among SOF cases, 33.8 years, was 3.6 years younger than the non-SOF cases (mean age: 37.3 years; p-value <0.05) and the non-SOF deployed cases (mean age: 38.4 years; p-value <0.001).

5.4. Comparison of Cancer Incidence Rates

After adjusting for age, sex, race and ethnicity, and component, the SOF cohort compared to the non-SOF cohort had a statistically significant 18% elevated risk of any cancer (IRR: 1.18, 95% CI: 1.12, 1.23), 33% elevated risk of melanoma of the skin (IRR: 1.33, 95% CI: 1.15, 1.53), and 21% elevated risk of testicular cancer (IRR: 1.21, 95% CI: 1.08, 1.35) (Table 4). All other cancer types were statistically similar between the two cohorts. Similar results were also seen when the SOF cohort was compared to the non-SOF deployed cohort. No statistically significant differences by cancer type were seen when comparing SOF operators to enablers.

5.5. Cancer Prevalence

Cancer prevalence for each cohort in 2024 are presented in Table 5. Similar to the IRR results, 2024 cancer prevalence was statistically higher in the SOF cohort compared to the non-SOF cohort for any cancer, melanoma of the skin, and testicular cancer. Additionally, the prevalence of brain and other nervous system cancers and non-Hodgkin's lymphoma were statistically higher among the SOF cohort compared to the non-SOF cohort, however the actual prevalence estimates for both cancers were only 0.01% higher. The prevalence analysis was not adjusted for founding between the cohorts.

5.6. Cancer Mortality

By the end of 2022, the most recent data available on deaths from the NDI data, there were 2,173 deaths from any cause among the SOF cohort, resulting in an overall mortality rate of 83.61 deaths per 100,000 py (Table 6). Of these, 103 deaths were due to cancer, resulting in a cancer mortality rate of 3.96 deaths per 100,000 py. The largest number of type specific cancer deaths were for brain and other nervous system cancers (19 deaths), colon and rectum cancers (16 deaths), and leukemia (14 deaths). The remaining cancer types each had less than 10 deaths during the surveillance period.

The SOF cohort mortality rates were all lower than the two comparison cohorts. The overall mortality rate for the non-SOF cohort was 130.08 deaths per 100,000 py, while the cancer-specific mortality rate was 6.60 deaths per 100,000 person-years (Table 6). Among the deployed non-SOF cohort, the overall mortality rate was 122.45 deaths per 100,000 person-years and the cancer-specific mortality rate was 5.86 deaths per 100,000 py (Table 6).

Table 2. Cancer Counts and Incidence Rates by Type and Study Cohort, 2001-2024

	SOF Cohort					Non-SOF Cohort				
Cancer type	**PY**	**Cases (N)**	**IR[a]**	**95% LL**	**95% UL**	**PY**	**Cases (N)**	**IR[a]**	**95% LL**	**95% UL**
Any cancer[b]	2,751,179	2,105	76.51	73.28	79.85	46,226,092	30,191	65.31	64.58	66.05
Colon and rectum	2,762,777	105	3.80	3.11	4.60	46,396,728	1,784	3.85	3.67	4.03
Pancreas	2,763,085	22	0.80	0.50	1.21	46,403,570	265	0.57	0.50	0.64
Lung and bronchus	2,763,081	25	0.90	0.59	1.34	46,402,124	613	1.32	1.22	1.43
Bones and joints	2,762,958	30	1.09	0.73	1.55	46,400,423	653	1.41	1.30	1.52
Melanoma (of the skin)	2,761,890	210	7.60	6.61	8.70	46,388,701	2,385	5.14	4.94	5.35
Breast, female	287,736	68	23.63	18.35	29.96	9,180,096	2,196	23.92	22.93	24.94
Prostate	2,475,001	31	1.25	0.85	1.78	37,210,393	715	1.92	1.78	2.07
Testis	2,472,637	345	13.95	12.52	15.51	37,185,600	3,975	10.69	10.36	11.03
Urinary bladder	2,763,085	16	0.58	0.33	0.94	46,402,256	373	0.80	0.72	0.89
Kidney and renal pelvis	2,762,871	66	2.39	1.85	3.04	46,399,501	1,126	2.43	2.29	2.57
Brain and other nervous system	2,762,516	116	4.20	3.47	5.04	46,393,944	1,749	3.77	3.60	3.95
Thyroid	2,762,219	154	5.58	4.73	6.53	46,385,083	2,913	6.28	6.05	6.51
Non-Hodgkin lymphoma	2,762,248	151	5.47	4.63	6.41	46,389,457	2,319	5.00	4.80	5.21
Leukemia	2,762,676	99	3.58	2.91	4.36	46,395,400	1,617	3.49	3.32	3.66

Abbreviations: SOF, Special Operation Forces; PY, person-years; N, number; LL, lower limit; UL, upper limit

[a]Incidence rate per 100,000 person-years

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

Table 3. Descriptive Statistics of Age at Diagnosis by Cancer Type and Study Cohort

	SOF Cohort				Non-SOF Cohort				Non-SOF Deployed Cohort			
Cancer type	**Min**	**Max**	**Mean[a]**	**Median[b]**	**Min**	**Max**	**Mean[a]**	**Median[b]**	**Min**	**Max**	**Mean[a]**	**Median[b]**
Any cancer[c]	18	62	33.2	33.0	17	82	33.2	32.0#	18	76	34.2#	33.0
Colon and rectum	21	57	35.8	36.0	17	79	36.0	36.0	18	71	36.7	36.0
Pancreas	21	42	35.1	35.0	18	72	37.5	37.0	19	68	37.9	37.0
Lung and bronchus	25	44	33.8	34.0	18	74	37.3*	35.0	19	70	38.4^	37.0
Bones and joints	20	41	29.6	29.5	17	64	27.9	26.0	19	64	29.8	28.0
Melanoma (of the skin)	20	54	32.8	33.0	18	72	32.5	32.0	18	72	33.0	32.0
Breast, female	22	49	36.4	36.5	19	68	37.5	37.0	21	68	37.7	37.0
Prostate	25	62	44.8	44.0	19	77	51.0#	52.0#	22	76	50.2^	51.0#
Testis	19	49	29.1	28.0	17	56	28.4*	28.0	18	52	29.5	29.0*
Urinary bladder	25	48	35.6	34.5	19	76	37.1	36.0	20	66	37.8	37.0
Kidney and renal pelvis	20	56	35.6	36.0	18	75	36.5	36.0	18	69	37.0	36.0
Brain and other nervous system	19	53	31.7	32.0	18	65	30.1*	29.0^	18	60	31.6	31.0
Thyroid	18	46	32.7	32.0	17	77	31.6*	31.0#	18	63	32.7	32.0
Non-Hodgkin lymphoma	19	45	31.2	31.0	17	80	30.5	29.0*	18	71	32.1	31.0
Leukemia	19	53	31.8	31.0	17	71	30.6	29.0*	19	65	32.7	32.0
Abbreviations: SOF, Special Operation Forces; Min, minimum; max, maximum.												
[a]Satterthwaite t-test used to compare mean values and generate a p-value.												
[b]Non-parametric Median test used to compare median values and generate a p-value.												
[c]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.												
*p-value <0.05												
^p-value <0.01												
#p-value <0.001												

Table 4. Cancer Crude and Adjusted Incidence Rate Ratio by Type and Cohort Comparison Groups, 2001-2024

	SOF vs. non-SOF cohorts				**SOF vs. non-SOF deployed cohorts**				**SOF: Operators vs. Enablers**			
Cancer type	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**
Any cancer[b]	1.17	**1.18**	**1.12**	**1.23**	1.09	**1.18**	**1.13**	**1.23**	1.00	1.01	0.92	1.11
Colon and rectum	0.99	0.98	0.80	1.19	0.87	0.97	0.79	1.18	1.05	1.12	0.74	1.70
Pancreas	1.39	1.52	0.98	2.35	1.14	1.37	0.87	2.14	0.52	0.52	0.19	1.44
Lung and bronchus	0.68	0.74	0.49	1.10	0.63	0.74	0.49	1.12	1.93	1.91	0.84	4.38
Bones and joints	0.77	0.78	0.54	1.12	0.88	0.88	0.61	1.29	0.89	0.88	0.40	1.92
Melanoma (of the skin)	1.48	**1.33**	**1.15**	**1.53**	1.29	**1.27**	**1.10**	**1.47**	0.97	0.83	0.62	1.11
Breast, female	0.99	0.99	0.77	1.25	0.78	0.93	0.73	1.19	0.92	0.89	0.38	2.06
Prostate	0.65	1.32	0.92	1.90	0.61	1.28	0.88	1.86	0.74	1.18	0.54	2.58
Testis	1.31	**1.21**	**1.08**	**1.35**	1.26	**1.22**	**1.09**	**1.36**	1.19	1.08	0.87	1.34
Urinary bladder	0.72	0.69	0.42	1.13	0.59	0.66	0.40	1.10	1.07	0.95	0.34	2.67
Kidney and renal pelvis	0.98	0.91	0.71	1.16	0.79	0.87	0.67	1.11	1.16	1.10	0.67	1.83
Brain and other nervous system	1.11	1.03	0.85	1.25	1.06	1.06	0.88	1.29	1.35	1.36	0.93	1.99
Thyroid	0.89	0.99	0.84	1.16	0.91	1.01	0.86	1.19	0.86	1.08	0.75	1.54
Non-Hodgkin lymphoma	1.09	1.06	0.90	1.25	1.03	1.06	0.90	1.26	0.85	0.86	0.60	1.22
Leukemia	1.03	0.99	0.81	1.22	1.00	1.04	0.84	1.28	1.06	1.02	0.67	1.55

Abbreviations: SOF, Special Operation Forces; IRR, incidence rate ratio; aIRR, adjusted incidence rate ratio; LL, lower limit; UL, upper limit.

[a]aIRR adjusted for age, sex, race/ethnicity, and component.

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

5.7. Description of SOF Cohort Any Cancer Cases

The 2,105 incident cases in the any cancer outcome for the SOF cohort consisted of 49 different cancer types (Appendix E). One fifth of these cases were for non-melanoma skin cancer. Testicular cancer, melanoma of the skin, thyroid cancer, and brain and other nervous system cancer cases rounded out the top five cancer diagnoses in the any cancer group.

5.8. Sensitivity Analyses

After applying a 10-year latency period to the analysis, the IRs for all cohorts increased, as expected since the denominator was smaller, but most of the cases occurred after 10 years of follow-up (Appendix F1). However, the adjusted IRR results remained similar to the full analysis, with a 25% and 23% increased risk of any cancer and a 32% and 28% increased risk of melanoma of the skin among the SOF cohort compared to the non-SOF cohort and the non-SOF deployed cohort, respectively (Appendix F2). However, the increased risk of testicular cancer was no longer statistically significant.

The second sensitivity analysis, restricting the study cohorts to active component service members, had the same findings as the main analysis, with the incidence rates of any cancer and melanoma of the skin significantly elevated among the SOF cohort compared to the non-SOF cohort (29% and 37% increased risk, respectively). However, the incidence rate of testicular cancer was no longer statistically elevated among the SOF cohort compared to the non-SOF cohorts (IRR: 1.18, 95% CI: 0.96, 1.44) (data not shown).

Removing the restriction on date of joining the military increased the number of subjects and the number of older individuals in each cohort, however the other demographics remained relatively similar (Table G1). As expected with older cohorts, the number of cancer cases and incidence rates increased substantially. There were 7,378 and 182,603 types of any cancer for the SOF cohort and the non-SOF cohort, respectively (Table G2). The incidence rate of any cancer more than doubled for the SOF cohort (164.06 per 100,000 py) and more than tripled for the non-SOF cohort (207.18 per 100,000 py) when compared to the main analysis results. However, the adjusted IRRs comparing the SOF cohort to the non-SOF cohort were attenuated compared to the main analysis. Significantly elevated risks of any cancer (9% increased risk), melanoma of the skin (22% increased risk), and testicular cancer (13% increased risk) were still found for the SOF cohort compared to the non-SOF cohort (Table G3). Additionally, in this sensitivity analysis, the risk of breast cancer was also significantly elevated (14% increased risk) among the SOF cohort compared to the non-SOF cohort. The mortality analysis yielded similar findings as the main analysis with the SOF cohort mortality rates all lower than the two comparison cohorts (data not shown). When the mean and median age of diagnosis for cases was compared between cohorts for this sensitivity analysis, the results were different from the main analysis. The mean and median age at diagnosis for all cancer types, except bone and joints and testicular cancer, were significantly lower among the SOF cohort compared to the non-SOF cohorts (Table G4). Differences in mean age ranged from 2.5 years (thyroid cancer) to 8.8 years (lung and bronchus cancer) younger for the SOF cases compared to the non-SOF cases.

Table 5. Cancer Prevalence by Type and Cohort, 2024

	SOF Cohort			Non-SOF Cohort			Non-SOF Deployed Cohort		
Cancer type	**Cases (N)**	**Population (N)**	**Prev (%)**	**Cases (N)**	**Population (N)**	**Prev (%)**	**Cases (N)**	**Population (N)**	**Prev (%)**
Any cancer[a]	**1,910**	**192,041**	**0.99**	24,373	3,137,837	0.78[α]	13,212	1,119,872	1.18[α]
Colon and rectum	76	192,041	0.04	1,289	3,137,837	0.04	724	1,119,872	0.06[α]
Pancreas	18	192,041	0.01	162	3,137,837	0.01*	99	1,119,872	0.01
Lung and bronchus	16	192,041	0.01	356	3,137,837	0.01	205	1,119,872	0.02^
Bones and joints	27	192,041	0.01	432	3,137,837	0.01	190	1,119,872	0.02
Melanoma (of the skin)	**199**	**192,041**	**0.10**	2,007	3,137,837	0.06[α]	1,150	1,119,872	0.10
Breast, female	65	21,582	0.30	1,898	668,286	0.28	892	176,648	0.50[α]
Prostate	29	170,459	0.02	635	2,469,551	0.03*	368	943,224	0.04[α]
Testis	**315**	**170,459**	**0.18**	3,246	2,469,551	0.13[α]	1,823	943,224	0.19
Urinary bladder	14	192,041	0.01	305	3,137,837	0.01	194	1,119,872	0.02^
Kidney and renal pelvis	60	192,041	0.03	912	3,137,837	0.03	570	1,119,872	0.05[#]
Brain and other nervous system	96	192,041	0.05	1,207	3,137,837	0.04*	623	1,119,872	0.06
Thyroid	147	192,041	0.08	2,498	3,137,837	0.08	1,234	1,119,872	0.11[α]
Non-Hodgkin lymphoma	135	192,041	0.07	1,771	3,137,837	0.06*	951	1,119,872	0.08*
Leukemia	79	192,041	0.04	1,158	3,137,837	0.04	604	1,119,872	0.05*

Table 5. Cancer Prevalence by Type and Cohort, 2024 (continued)

	SOF: Operators			SOF: Enablers		
Cancer type	**Cases (N)**	**Population (N)**	**Prev (%)**	**Cases (N)**	**Population (N)**	**Prev (%)**
Any cancer[a]	684	66,434	1.03	1,226	125,607	0.98
Colon and rectum	26	66,434	0.04	50	125,607	0.04
Pancreas	5	66,434	0.01	13	125,607	0.01
Lung and bronchus	9	66,434	0.01	7	125,607	0.01
Bones and joints	9	66,434	0.01	18	125,607	0.01
Melanoma (of the skin)	68	66,434	0.10	131	125,607	0.10
Breast, female	6	2,011	0.30	59	19,571	0.30
Prostate	8	64,423	0.01	21	106,036	0.02
Testis	138	64,423	0.21	177	106,036	0.17
Urinary bladder	5	66,434	0.01	9	125,607	0.01
Kidney and renal pelvis	23	66,434	0.03	37	125,607	0.03
Brain and other nervous system	39	66,434	0.06	57	125,607	0.05
Thyroid	49	66,434	0.07	98	125,607	0.08
Non-Hodgkin lymphoma	45	66,434	0.07	90	125,607	0.07
Leukemia	29	66,434	0.04	50	125,607	0.04

Abbreviations: SOF, Special Operation Forces; N, number; Prev, prevalence; %, percentage

[a]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

*p-value <0.05

^p-value <0.01

#p-value <0.001

αp-value <0.0001

Table 6. Cancer Deaths and Mortality Rate by Type and Cohort, 2001-2022

	SOF Cohort			Non-SOF Cohort			Non-SOF Deployed Cohort		
	PY	**Deaths (N)**	**MR[a]**	**PY**	**Deaths (N)**	**MR[a]**	**PY**	**Deaths (N)**	**MR[a]**
Any Cause of Death	2,598,888	2,173	83.61	55,465,669	72,150	130.08	23,786,424	29,126	122.45
Cancer Deaths by Type									
Any cancer[b]	2,598,888	103	3.96	55,465,669	3,662	6.60	23,786,424	1,393	5.86
Colon and rectum	2,598,888	16	0.62	55,465,669	438	0.79	23,786,424	189	0.79
Pancreas	2,598,888	2	0.08	55,465,669	114	0.21	23,786,424	42	0.18
Lung and bronchus	2,598,888	7	0.27	55,465,669	239	0.43	23,786,424	83	0.35
Bones and joints	2,598,888	2	0.08	55,465,669	101	0.18	23,786,424	40	0.17
Melanoma (of the skin)	2,598,888	5	0.19	55,465,669	150	0.27	23,786,424	62	0.26
Breast, female	260,814	1	0.38	10,858,534	230	2.12	3,198,167	60	1.88
Prostate	2,338,074	0	0.00	44,607,135	17	0.04	20,588,257	7	0.03
Testis	2,338,074	3	0.13	44,607,135	119	0.27	20,588,257	43	0.21
Urinary bladder	2,598,888	0	0.00	55,465,669	18	0.03	23,786,424	7	0.03
Kidney and renal pelvis	2,598,888	3	0.12	55,465,669	76	0.14	23,786,424	25	0.11
Brain and other nervous system	2,598,888	19	0.73	55,465,669	440	0.79	23,786,424	183	0.77
Thyroid	2,598,888	1	0.04	55,465,669	9	0.02	23,786,424	6	0.03
Non-Hodgkin lymphoma	2,598,888	3	0.12	55,465,669	174	0.31	23,786,424	68	0.29
Leukemia	2,598,888	14	0.54	55,465,669	335	0.60	23,786,424	130	0.55

Table 6. Cancer Deaths and Mortality Rate by Type and Cohort, 2001-2022 (continued)

	SOF: Operators			SOF: Enablers		
	PY	Deaths (N)	MR[a]	PY	Deaths (N)	MR[a]
Any Cause of Death	930,235	1,063	114.27	1,668,653	1,110	66.52
Cancer Deaths by Type						
Any cancer[b]	930,235	40	4.30	1,668,653	63	3.78
Colon and rectum	930,235	4	0.43	1,668,653	12	0.72
Pancreas	930,235	0	0.00	1,668,653	2	0.12
Lung and bronchus	930,235	2	0.21	1,668,653	5	0.30
Bones and joints	930,235	1	0.11	1,668,653	1	0.06
Melanoma (of the skin)	930,235	2	0.21	1,668,653	3	0.18
Breast, female	24,851	0	0.00	235,963	1	0.42
Prostate	905,385	0	0.00	1,432,689	0	0.00
Testis	905,385	1	0.11	1,432,689	2	0.14
Urinary bladder	930,235	0	0.00	1,668,653	0	0.00
Kidney and renal pelvis	930,235	2	0.21	1,668,653	1	0.06
Brain and other nervous system	930,235	11	1.18	1,668,653	8	0.48
Thyroid	930,235	1	0.11	1,668,653	0	0.00
Non-Hodgkin lymphoma	930,235	2	0.21	1,668,653	1	0.06
Leukemia	930,235	4	0.43	1,668,653	10	0.60

Abbreviations: SOF, Special Operation Forces; N, number; PY, person-years; MR, mortality rate.

[a]Mortality rate per 100,000 PY

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

6. Discussion

6.1. Summary

This study found that after adjusting for age, sex, race and ethnicity, and component the SOF cohort had an 18% higher risk of any type of cancer, a 33% higher risk of melanoma of the skin, and a 21% higher risk of testicular cancer compared to the non-SOF cohort. These elevated risks were still found when restricting the comparison cohort to deployed non-SOF service members and in the sensitivity analyses. No statistically significant differences by cancer type were seen when comparing SOF operators to enablers. Additionally, the overall and type specific cancer mortality rates were all lower for the SOF cohort when compared to the non-SOF cohorts.

6.1.1. Cancer Incidence

The findings of this study are different than what was found in the 2016 SOCOM cancer report. In the prior report, urinary bladder cancer was the only cancer with an elevated risk among the SOF cohort. However, the bladder cancer case count was quite small, and the findings may have been impacted by the limitations of the study. This updated analysis was able to improve upon many of those limitations, including using a more accurate methodology to identify the SOF population, standardization of the study cohort ages by requiring all subjects to enter the military during the study period, and inclusion of more robust outcome data from both the DoD and the VA.

Melanoma of the skin had the highest increased risk among the SOF cohort compared to the other comparison cohorts. It was also the second most frequent cancer type of the 14 evaluated. Ultraviolet (UV) light is a major risk factor for melanoma of the skin, with sunlight being the main source of UV light.[18] Given the occupational exposure characteristics of the SOF population, frequent deployments, and likelihood of being deployed to austere environments where access to appropriate sun protection may be limited, a higher UV exposure may be a key factor for increased risk of melanoma of the skin among the SOF cohort. However, studies specifically designed to investigate this risk will be needed to determine this association.

Testicular cancer was the most frequent cancer type and had the highest incidence rate among males for the cancers evaluated in this study for both the SOF cohort and the non-SOF cohorts. A previous publication found testicular cancer to have the 3rd highest incidence rate of cancers among the active component general military population in 2022, second only to female breast cancer and melanoma of the skin.[6] As the study populations were relatively young, given the requirement to start military service during the study period, it is not surprising that testicular cancer was the most frequent cancer diagnosis. Testicular cancer is most common in males in their late 20 to early 30s.[19] This is likely why testicular cancer was no longer elevated in the 10-year latency sensitivity analysis, since 67% of the total testicular cases were dropped in that analysis, compared to a range of 19-63% cases dropped for the other cancer types.

Reasons for the increased risk of testicular cancer among the SOF cohort will need to be explored in separate studies. The majority of known risk factors for testicular cancer are either factors not solely associated with serving in the Special Forces, undescended testicle and family history, or factors adjusted for in the analysis, age and race and ethnicity.[20, 21] Studies on potential occupational and environmental risk factors for testicular cancer have had mixed findings, but include exposure to endocrine disrupting factors that are seen in firefighting and military occupations, and exposure to pesticides.[20, 22]

The study found an 18% higher adjusted risk of any cancer for the SOF cohort compared to the non-SOF cohorts. After evaluating the cancers that make up this category for SOF, the two cancers that were also independently higher among the SOF cohort, testicular and melanoma of the skin, were the 2nd and 3rd most frequent cancer in this group. The most frequent cancer was non-melanoma skin cancer. Although less severe than melanoma skin cancer, risk factors are similar for all skin cancer types.[18, 23] These 3 cancers are likely driving this higher risk in the any cancer group among the SOF cohort. However, less frequent cancers in this list may need to be evaluated as more cases appear, as this will provide more statistical power to identify significant difference between the cohorts.

6.1.2. Age at Diagnosis

One of the objectives of the study was to evaluate whether cancers occur at a younger age among the SOF cohort. The results of this study do not indicate a younger age of cancer onset among the SOF cohort for most of the cancer types. However, the study did find the median age of prostate cancer diagnosis among the SOF cohort was 8 years younger than the non-SOF cohorts, although the incidence rate of prostate cancer was similar between the cohorts. Risk factors for early onset prostate cancer, defined as men under 55 years of age at diagnosis, have been reported to include family history, genetic factors, and occupations, such as firefighters and military personnel. [24, 25] The sensitivity analysis that removed the requirement to start military service in 2001 or later, did find the mean and median age of most cancers among the SOF cohort were statistically lower than cases in the non-SOF cohort. Reasons for this may be multifactorial and may include earlier screening, better awareness of symptoms, increased concerns about cancer risk leading to earlier testing among the SOF cohort, or differential exposures to cancer risk factors.

6.1.3. Cancer Mortality

A reassuring finding of the study was a lower mortality rate among the SOF cohort compared to the other cohorts for overall mortality and cancer specific mortality. Overall mortality was 36% lower and cancer-specific mortality was 40% lower among the SOF cohort compared to the non-SOF cohort. As these cohorts were relatively young, with the majority of subjects in any of the cohorts under 45 years of age at end of follow-up, these findings may change as the cohorts age. Additionally, as the study only includes service members who started service during the study period, these results are not comprehensive of all deaths, cancer related or otherwise, occurring among the entire SOF population or the general US military population.

6.2. Study Strengths

This is one of only two studies that have conducted comprehensive surveillance of the incidence, prevalence, and mortality of cancer among the SOF population. This study was designed to improve upon limitations of the prior study and incorporated a much broader ascertainment of outcomes by utilizing both the DOD and VA data on cancer. This study followed a large cohort of service members throughout their military career and after leaving service. The inclusion of data from the VA and the NDI allowed for longer follow-up and better ascertainment of cancer cases and deaths. Another strength of the study is that the sensitivity analyses had similar results as the main analysis, demonstrating the robustness and validity of the main study findings.

6.3. Study Limitations

Although multiple data sources were utilized to identify cancer cases among the study populations, the study was not able to capture cancer encounters/diagnoses that occurred outside of the DoD and VA medical care that were not billed through TRICARE or the VA. If service members were seeking care at private medical facilities and utilizing private insurance to pay for the care, then those diagnoses would not be captured in this analysis. This may occur for service member who are no longer eligible for TRICARE, such as non-activated guard and reservists and those who left military service and chose to use private insurance as opposed to VA health care. This could lead to an underestimate of the true cancer incidence and prevalence rates among these populations. To account for differences in the proportion of reserve and guard members between the SOF and non-SOF cohorts, component was added to the adjusted model. Additionally, we evaluated the proportion of each cohort who received VA medical care and found it to be similar, at 44% and 46%, for the SOF and non-SOF cohorts, respectively. Therefore, although cancer IRs may be lower than the true rates, it is not expected that this would differ between the cohorts nor impact the main findings of this study.

Another limitation is that different cancer case definitions were used for the DoD and VA encounter data. Cases were identified from the DoD encounter data using the AFHSD standardized cancer case definition, which required the cancer diagnosis to be in the first or second diagnostic position. However, the VA encounter data only had one diagnosis per record, without an indication of whether this was a primary or subsequent diagnosis during the encounter. Therefore, the modified cancer case definition for the VA encounter data was less strict and could capture non-incident or rule-out cancer diagnoses. This could result in an overestimate of the cancer incidence, but given this is not expected to be differential between the study cohorts, it should not impact the comparison of the incidence rates.

To further improve cancer case ascertainment, future studies could incorporate state cancer registry data. However, this is currently a lengthy process that was not feasible for this current study. Additionally, the study could not investigate nor compare the complexity, stage, and severity of cancer due to a lack of complete data on these factors from all the data sources utilized to define the cancer cases. Mortality data was only available through 2022, so as more recent data become available, it may be necessary to update these analyses to see if difference in mortality rates emerge.

The study was designed as a retrospective cohort study to provide cancer surveillance data. It was not designed to investigate specific cancer related risk factors, but merely to identify if the risk of cancer was higher among the SOF cohort compared to the non-SOF cohort. Therefore, the "exposure" in the study was simply being in the SOF cohort. Not all SOF personnel experience the same exposures during their military career, so the individual risk of developing cancer may differ between SOF members and cannot be assessed in this analysis. The study did not identify differences in cancer incidence rates between the SOF operators and enablers. This may be due to a smaller number of cases in each group, limiting the power of the study to detect significant difference. Additionally, designation as a SOF operator was defined as having an operator occupational specialty code at any point in service. This may have misclassified individuals as operators if they were only an operator briefly and then changed to a SOF enabler. Data on location history, environmental exposures, and lifestyle factors were not available and therefore couldn't be accounted for the analysis.

The study did not compare SOF cancer rates to civilian cancer rates. As the civilian population is quite different from the general U.S. military population, and specifically the SOF population, in terms of age, sex, race and ethnicity, health status, access to care, and potential exposures, it was decided that a more appropriate comparison for the SOF cohort would be service members who were never a part of SOF. Additionally, it would be difficult to match the exact methodology used to calculate the civilian cancer incidence rates produced by SEER, adding potential bias to a study comparing SOF to the civilian population.

6.4. Conclusions

The findings of this study indicate that SOF service members who joined the military in 2001 or later had a higher incidence of cancer compared to service members who joined during the same time period but were never a part of SOF. As this is a younger cohort and does not include service members who joined the military prior to 2001, the results of this study may not be applicable to the entire SOF population. However, the sensitivity analysis that removed the military start date requirement found similar findings and strengthens the validity and applicability of the main findings to the larger SOF population. The study was not designed to determine or evaluate risk factors for cancers or reasons for the increased risk among the SOF population. Although the risk of cancer was higher among the SOF cohort compared to the non-SOF cohort, cancer mortality rates were found to be significantly lower. As with any study, the results should be interpreted in the context of the limitations.

6.5. Future Studies

Several of the cancer types had low counts among the SOF cohorts, making it difficult statistically to determine if there was an increased risk of these cancers. As the study cohorts age, the counts and incidence rates of cancers will likely increase. Whether or not these increases will be differential between the two cohorts is unknown and will require additional follow-up studies to evaluate these changes. Additionally, if data from state cancer registries become more readily available, it will be worthwhile to repeat this study with a more complete capture of cancer cases not identified through DoD and VA medical data and registries. This study could not address two of the questions asked in the SOCOM public health assessment request related to factors that contribute to the cancer risk in the SOF population and whether the military health system is able to detect early cancer and provide holistic, integrated cancer care commensurate with national averages and treatment outcomes (Appendix B). Those two questions require data not available within the AFHSD and outside the scope of this study. However, if data on personal exposures, risk factors, deployment locations, military health system cancer screening and treatments, etc. become available within SOCOM or other agencies, it may be warranted to evaluate these factors, specifically in relation to testicular cancer and melanoma of the skin.

7. References

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Appendix A: Acronyms

AFHSD	Armed Forces Health Surveillance Division
aIRR	Adjusted incidence rate ratio
CDW	Corporate Date Warehouse
CI	Confidence interval
DHA	Defense Health Agency
DMSS	Defense Medical Surveillance System
DoD	Department of Defense
DSPO	Defense Suicide Prevention Office
DoD CR	Department of Defense Cancer Registry
ICD	International Classification of Diseases
IR	Incidence rate
IRR	Incidence rate ratio
NCI	National Cancer Institute
NDI	National Death Index
PY	Person-years
SEER	Surveillance, Epidemiology, and End Results
SOCOM	Special Operations Command
SOF	Special Operation Forces
UV	Ultraviolet
VA	Department of Veterans Affairs
VACCR	Veterans Affairs Central Cancer Registry

Appendix B: United States Special Operations Command Memo

UNITED STATES SPECIAL OPERATIONS COMMAND
OFFICE OF THE COMMANDER
7701 TAMPA POINT BOULEVARD
MACDILL AIR FORCE BASE, FLORIDA 33621-5323

27 September 2023

MEMORANDUM FOR ASSISTANT SECRETARY OF DEFENSE FOR HEALTH AFFAIRS, DEFENSE HEALTH HEADQUARTERS, 7700 ARLINGTON BOULEVARD, SUITE 5101, FALLS CHURCH, VA 22042-5101

SUBJECT: Request Public Health Assessment for United States Special Operations Command

1. REFERENCES:

a. Public Health Assessment of Cancer Incidence Among Special Operations Forces, Armed Forces Health Surveillance Branch, 16 August 2016.

b. Phase 1-a – Study on the Incidence of Cancer Diagnosis and Mortality Among Military Aviators and Aviation Support Personnel, Department of Defense, January 2023.

2. The U.S. Special Operations Command (USSOCOM) requests support and partnership to conduct a public health assessment of the impacts of cancer in the Special Operations Forces (SOF) population. This effort will assess cancer incidence, prevalence, types, and characteristics through analysis of population-level administrative and medical data.

3. Since completion of the initial study in 2016, the perceived impact of cancer among the SOF population has intensified as cases continue to rise. Studies conducted on military aviators and U.S. Army Special Operations Forces (Choi, et. al., pending publication) confirming higher incidence of cancer in subsets of the Department of Defense (DoD) population have contributed to continued concerns. The 2016 study of cancer in SOF identified significant limitations that truncated the full exploration of the issue.

4. As part of this renewed effort, USSOCOM will provide active, ongoing participation in the study to minimize study limitations identified in previous efforts. The initial study objectives are to determine:

a. Are there are significant or distinct differences in SOF and non-SOF cancer diagnoses within the DoD? Compared to civilian populations? (e.g., incidence, types, rarity, complexity, age of onset, or severity, etc.)

b. Are there distinct differences in assessed and selected SOF personnel and SOF support personnel?

c. Are there identifiable trends, characteristics, exposures, or other factors among the SOF population that contribute to cancer risk?

d. Is the military health system able to detect early cancer and provide holistic, integrated cancer care commensurate with national averages and treatment outcomes?

5. Request additional partnership with the National Institutes of Health, the National Cancer Center, and the Veteran's Health Administration to provide comparative populations and analysis of health outcomes to fully realize study aims.

6. The intent of this study is to maintain operational readiness within the Nation's elite fighting force often exposed to health hazards in the performance of their unique missions and bolster Service member's confidence in their health and wellness. This study is part of a larger cancer effort that stresses the importance of routine screenings, empowers individuals in wellness endeavors, and reduces unhealthy lifestyle habits. We aim to identify areas of early intervention to reduce the impacts of cancer on our force, as well as enable innovation for prevention and treatment.

7. Points of contact for this effort are COL April Verlo, april.verlo@socom.mil, 813-453-9295; and LTC Gabrielle Caldera, gabrielle.caldera@socom.mil, 813-826-5051.

BRYAN P. FENTON
General, U.S. Army
Commander

Appendix C: Major Command Codes for Identification of Special Operation Forces by Service

Service	Major Command Code
Army	SP
	DJ
Air Force	0V
	3D
Navy	088
Marine Corps	068
	078
	080
	094
	1C0
	1GF
	1ML
	1MR
	1MS
	1MT
	1MU
	1MW
	1MX
	1MY
	1MZ
	1S8
Headquarters/Theater Special Operations Command	N03
	N1C
	NA9
	NBM
	NBS
	NBW
	NE7
	NEQ
	NFF
	NGF
	NGS
	NVS
	QAQ
	T0C
	T12
	T84

	T91
	TB4
	TF9
	TJ5
	TJT
	TL8
	TWE
	TX1
	TZ7
	UAS
	UCG

Appendix D: International Classification of Diseases, 9th and 10th Revision (ICD-9 and ICD-10) Codes used to Define Cancer Cases

Cancer Type	ICD-9	ICD-10	Selected Cancer
Aleukemic, subleukemic and NOS	203.1, 207.1, 207.8, 208.1-208.2, 208.8-208.9	C90.1, C91.5, C94.1, C94.3, C94.7, C95.1, C95.9, C94.8	N
Anus, anal canal and anorectum	154.2-154.3, 154.8	C21	N
Bones and joints	170	C40, C41	Y
Brain and other nervous system	191, 192	C70, C71, C72	Y
Breast, female	174	C50	Y
Cervix uteri	180	C53	N
Colon and rectum	153, 154.0-154.1, 159.0	C18-C20, C260	Y
Corpus uteri	182	C54	N
Esophagus	150	C15	N
Eye and orbit	190	C69	N
Floor of mouth	144	C04	N
Gallbladder	156	C23	N
Gum and other mouth	143, 145	C03, C05, C06	N
Hodgkin lymphoma	201	C81	N
Hypopharynx	148	C12, C13	N
Intrahepatic bile duct	155.1	C221	N
Kaposi sarcoma	176	C46	N
Kidney and renal pelvis	189.0, 189.1	C64-C65	Y
Larynx	161	C32	N
Leukemia	204-208	C91-C95	Y
Lip	140	C00	N
Liver	155.0, 155.2	C22.0, C22.2- C22.9	N
Lung and bronchus	162.2-162.5, 162.8-162.9	C34	Y
Melanoma (of the skin)	172	C43	Y
Mesothelioma	N/A	C45	N
Miscellaneous malignant cancer	159.1, 195-199, 202.3, 202.5-202.6, 203.8	C26.1, C45.7, C45.9, C76-C80, C88, C94.6, C96.0-C96.2, C96.4-C96.8, C97	N
Myeloma	203.0, 238.6	C90.0, C90.2, C90.3	N
Nasopharynx	147	C11	N
Non-Hodgkin lymphoma	200, 202.0-202.2, 202.7, 202.8.273.3	C82-C86, C88 (exclude C88.8 and C88.9)	Y
Non-melanoma (skin)	173	C44	N
Nose, nasal cavity and middle ear	160	C30, C31	N
Oropharynx	146.3-146.9	C10	N

Other biliary	156.1-156.2, 156.8-156.9	C24	N
Other digestive organs	159.8, 159.9	C26.8-C26.9, C48.8	N
Other endocrine including thymus	164.0, 194	C37, C74, C75	N
Other female genital organs	181, 183.2-183.5, 183.8-183.9, 184.8-184.9	C57, C58	N
Other male genital organs	187.5-187.9	C63	N
Other oral cavity and pharynx	149	C14	N
Other urinary organs	189.3, 189.4, 189.8, 189.9	C68	N
Ovary	183	C56	N
Pancreas	157	C25	Y
Penis	187.1-187.4	C60	N
Peritoneum, omentum and mesentery	158.8, 158.9	C45.1, C48.1, C48.2	N
Pleura	163	C38.4, C45.0	N
Prostate	185	C61	Y
Retroperitoneum	158	C48.0	N
Salivary gland	142	C07, C08	N
Small intestine	152	C17	N
Soft tissue including heart	164.1, 171	C47, C49, C38.0, C45.2	N
Stomach	151	C16	N
Testis	186.0, 186.9	C62.0, C62.1, C62.9	Y
Thyroid	193	C73	Y
Tongue	141	C01, C02	N
Tonsil	146.0-146.2	C09	N
Trachea, mediastinum and other respiratory organs	162.0, 164.2, 164.3, 164.8, 164.9, 165	C33, C38.1-C38.3, C38.8, C39	N
Ureter	189.2	C66	N
Urinary bladder	188	C67	Y
Uterus, NOS	179	C55	N
Vagina	184	C52	N
Vulva	184.1-184.4	C51	N

Table E. Description of Cancers in the Any Cancer Outcome, Restricted to First Cancer Diagnosis: SOF Cohort, 2001-2024

Cancer type[a]	N	% of Total
Non-melanoma skin	460	21.85
Testis	330	15.68
Melanoma (of the skin)	199	9.45
Miscellaneous malignant cancer	149	7.08
Thyroid	144	6.84
Brain and other nervous system	109	5.18
Colon and rectum	98	4.66
Non-Hodgkin lymphoma	96	4.56
Hodgkins lymphoma	82	3.90
Breast	69	3.28
Kidney and renal pelvis	62	2.95
Soft tissue including heart	41	1.95
Prostate	27	1.28
Bones and joints	20	0.95
Lung and bronchus	20	0.95
Leukemia	17	0.81
Cervix uteri	16	0.76
Urinary bladder	16	0.76
Pancreas	15	0.71
Ovary	12	0.57
Liver	10	0.48
Salivary gland	10	0.48
Stomach	10	0.48
Gum and other mouth	8	0.38
Other endocrine including thymus	8	0.38
Tongue	8	0.38
Myeloma	7	0.33
Retroperitoneum	7	0.33
Aleukemic, subleukemic and NOS	5	0.24
Esophagus	5	0.24
Eye and orbit	5	0.24
Small intestine	5	0.24
Nasopharynx	4	0.19
Other endocrine including thymus	4	0.19
Corpus uteri	3	0.14
Larynx	3	0.14

Lip	3	0.14
Mesothelioma	3	0.14
Trachea, mediastinum and other respiratory organs	3	0.14
Intrahepatic bile duct	2	0.10
Tonsil	2	0.10
Other male genital organs	2	0.10
Nose, nasal cavity and middle ear	1	0.05
Other digestive organs	1	0.05
Other female genital organs	1	0.05
Other oral cavity and pharynx	1	0.05
Peritoneum, omentum, and mesentery	1	0.05
Kaposi Sarcoma	1	0.05

Abbreviations: SOF, Special Operation Forces; N, number; %, percentage;

[a]This descriptive table was restricted to the first occurring cancer diagnosis for each subject in the SOF cohort. Combined, they are classified as “any cancer" for the other tables in this report. Counts for this table may differ from the 14 specific cancer type counts presented in the main analysis, as each of those cancers were evaluated separately and did not account for other diagnoses of a cancer prior to the cancer type of interest.

Appendix F

Table F1: Sensitivity Analysis - 10-Year Latency Period: Cancer Counts and Incidence Rates by Type and Study Cohort, 2001-2024

	SOF Cohort					Non-SOF Cohort					Non-SOF Deployed Cohort				
Cancer type	**PY**	**Cases (N)**	**IR[a]**	**95% LL**	**95% UL**	**PY**	**Cases (N)**	**IR[a]**	**95% LL**	**95% UL**	**PY**	**Cases (N)**	**IR[a]**	**95% LL**	**95% UL**
Any cancer[b]	892,802	1,197	134.07	126.58	141.89	13,125,556	14,792	112.70	110.89	114.53	8,733,874	9,641	110.39	108.19	112.61
Colon and rectum	897,088	74	8.25	6.48	10.36	13,177,469	1,086	8.24	7.76	8.75	8,768,885	733	8.36	7.76	8.99
Pancreas	897,247	15	1.67	0.94	2.76	13,180,270	158	1.20	1.02	1.40	8,770,831	113	1.29	1.06	1.55
Lung and bronchus	897,244	17	1.89	1.10	3.03	13,179,779	330	2.50	2.24	2.79	8,770,484	222	2.53	2.21	2.89
Bones and joints	897,250	11	1.23	0.61	2.19	13,180,070	154	1.17	0.99	1.37	8,770,739	99	1.13	0.92	1.37
Melanoma (of the skin)	896,922	108	12.04	9.88	14.54	13,176,130	1,105	8.39	7.90	8.90	8,767,909	750	8.55	7.95	9.19
Breast, female	92,309	52	56.33	42.07	73.87	2,586,226	1,497	57.88	54.99	60.89	1,299,758	764	58.78	54.69	63.10
Prostate	804,746	23	2.86	1.81	4.29	10,587,185	552	5.21	4.79	5.67	7,467,397	340	4.55	4.08	5.06
Testis	804,285	113	14.05	11.58	16.89	10,583,599	1,246	11.77	11.13	12.45	7,464,418	907	12.15	11.37	12.97
Urinary bladder	897,239	13	1.45	0.77	2.48	13,179,753	227	1.72	1.51	1.96	8,770,464	163	1.86	1.58	2.17
Kidney and renal pelvis	897,126	46	5.13	3.75	6.84	13,178,121	764	5.80	5.39	6.22	8,769,343	535	6.10	5.59	6.64
Brain and other nervous system	897,039	57	6.35	4.81	8.23	13,178,455	625	4.74	4.38	5.13	8,769,449	448	5.11	4.65	5.60
Thyroid	896,892	90	10.03	8.07	12.33	13,175,222	1,282	9.73	9.20	10.28	8,767,628	791	9.02	8.40	9.67
Non-Hodgkin lymphoma	897,018	71	7.92	6.18	9.98	13,177,296	883	6.70	6.27	7.16	8,768,649	618	7.05	6.50	7.63
Leukemia	897,069	54	6.02	4.52	7.85	13,178,026	633	4.80	4.44	5.19	8,769,372	442	5.04	4.58	5.53

Abbreviations: SOF, Special Operation Forces; PY, person-years; N, number; LL, lower limit; UL, upper limit

[a]incidence rate per 100,000 person-years

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

Table F2. Sensitivity Analysis - 10-Year Latency Period: Cancer Crude and Adjusted Incidence Rate Ratio by Type and Cohort Comparison Groups, 2001-2024

	SOF vs. non-SOF cohorts				SOF vs. non-SOF deployed cohorts				SOF: Operators vs. Enablers			
Cancer type	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**
Any cancer[b]	1.19	**1.25**	**1.18**	**1.33**	1.21	**1.23**	**1.15**	**1.30**	0.94	0.98	0.86	1.11
Colon and rectum	1.00	1.03	0.81	1.31	0.99	0.99	0.78	1.27	1.10	1.25	0.77	2.04
Pancreas	1.39	1.58	0.92	2.71	1.30	1.45	0.84	2.51	0.43	0.53	0.14	1.97
Lung and bronchus	0.76	0.87	0.53	1.43	0.75	0.83	0.50	1.37	1.51	1.60	0.59	4.38
Bones and joints	1.05	1.00	0.54	1.86	1.09	1.06	0.57	1.99	0.17	0.15	0.02	1.17
Melanoma (of the skin)	1.44	**1.32**	**1.08**	**1.61**	1.41	**1.28**	**1.05**	**1.57**	0.75	**0.63**	**0.42**	**0.96**
Breast, female	0.97	1.01	0.76	1.33	0.96	0.99	0.74	1.31	0.80	0.79	0.28	2.22
Prostate	0.55	1.17	0.77	1.79	0.63	1.11	0.72	1.72	0.65	1.08	0.43	2.74
Testis	1.19	1.10	0.91	1.34	1.16	1.08	0.89	1.32	0.88	0.80	0.54	1.17
Urinary bladder	0.84	0.85	0.49	1.50	0.78	0.81	0.46	1.43	0.76	0.71	0.22	2.34
Kidney and renal pelvis	0.88	0.85	0.63	1.14	0.84	0.82	0.61	1.11	1.43	1.37	0.75	2.49
Brain and other nervous system	1.34	1.23	0.94	1.62	1.24	1.14	0.86	1.50	1.33	1.36	0.79	2.36
Thyroid	1.03	1.14	0.92	1.41	1.11	1.14	0.91	1.41	0.77	1.07	0.67	1.73
Non-Hodgkin lymphoma	1.18	1.12	0.88	1.43	1.12	1.09	0.85	1.40	1.04	0.96	0.59	1.57
Leukemia	1.25	1.22	0.93	1.62	1.19	1.19	0.89	1.58	1.17	1.14	0.65	2.00

Abbreviations: SOF, Special Operation Forces; IRR, incidence rate ratio; aIRR, adjusted incidence rate ratio; LL, lower limit; UL, upper limit

[a]aIRR adjusted for age, sex, race/ethnicity, and component

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

Appendix G

Table G1. Sensitivity Analysis - Non-Restricted Military Service Start: Characteristics of Study Cohorts: 2001-2023

	SOF Cohort		Non-SOF Cohort		Non-SOF Deployed Cohort	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**
Total individuals	312,644	100.0	7,463,707	100.0	2,752,751	100.0
Sex						
Male	281,327	90.0	6,073,547	81.4	2,404,694	87.4
Female	31,317	10.0	1,390,160	18.6	348,057	12.6
Age at entry into cohort (years)						
< 20	108,650	34.8	2,965,897	39.7	961,886	34.9
20-24	126,126	40.3	2,333,857	31.3	868,582	31.6
25-29	42,579	13.6	824,859	11.1	331,748	12.1
30-34	19,087	6.1	509,274	6.8	243,646	8.9
35-39	10,847	3.5	413,870	5.6	189,826	6.9
40-44	4,081	1.3	221,645	3.0	96,346	3.5
45-49	985	0.3	106,422	1.4	39,329	1.4
50-54	257	0.1	64,300	0.9	17,576	0.6
55-59	29	0.0	22,201	0.3	3,588	0.1
60-64	3	0.0	1,176	0.0	199	0.0
65+	0	0.0	206	0.0	25	0.0
Race/ethnicity						
Non-Hispanic, White	211,279	67.6	4,472,007	59.9	1,738,606	63.2
Non-Hispanic, Black	35,848	11.5	1,232,773	16.5	432,305	15.7
Hispanic	37,703	12.1	965,422	12.9	319,103	11.6
Non-Hispanic Other	27,814	8.9	793,505	10.6	262,737	9.5
Service at entry into cohort						
Army	160,794	51.4	3,613,991	48.4	1,214,322	44.1
Navy	11,314	3.6	1,451,638	19.5	587,671	21.4
Air Force	87,223	27.9	1,387,684	18.6	564,590	20.5
Marine Corps	53,197	17.0	1,007,978	13.5	385,603	14.0
Coast Guard	116	0.0	2,416	0.0	565	0.0
Service at exit from cohort						
Army	165,390	52.9	3,654,685	49.0	1,241,459	45.1
Navy	10,284	3.3	1,433,992	19.2	576,069	20.9
Air Force	87,475	28.0	1,414,420	19.0	574,181	20.9
Marine Corps	49,341	15.8	955,438	12.8	360,077	13.1
Coast Guard	154	0.1	5,172	0.1	965	0.0

Component at entry into cohort						
Active	292,801	93.7	4,933,943	66.1	2,108,201	76.6
Reserve	9,786	3.1	1,108,304	14.9	274,610	10.0
Guard	10,057	3.2	1,421,460	19.0	369,940	13.4
Grade at entry into cohort						
Enlisted	275,391	88.1	6,866,531	92.0	2,489,621	90.4
Officer	37,253	11.9	597,176	8.0	263,130	9.6
Grade at exit from cohort						
Enlisted	236,682	75.7	6,608,544	88.5	2,367,826	86.0
Officer	75,962	24.3	855,163	11.5	384,925	14.0
Year of entry into military service						
1970-2000	80,911	25.9	2,309,406	30.9	1,138,817	41.4
2001-2009	100,196	32.1	2,155,074	28.9	1,124,121	40.8
2010-2019	106,399	34.0	2,230,430	29.9	469,315	17.1
2020-2023	25,138	8.0	768,797	10.3	20,498	0.7
Occupation at exit from cohort						
Infantry/artillery/combat engineering	77,058	24.7	987,532	13.2	432,961	15.7
Armor/motor transport	4,819	1.5	367,340	4.9	145,502	5.3
Pilot/aircrew	16,331	5.2	159,226	2.1	91,457	3.3
Repair/engineering	60,993	19.5	1,965,713	26.3	826,834	30.0
Comm/intel	82,946	26.5	1,604,616	21.5	620,651	22.6
Healthcare	12,415	4.0	570,584	7.6	168,381	6.1
Other	58,082	18.6	1,808,696	24.2	466,965	17.0
Length of follow-up (years)						
<5	41,631	13.3	2,176,332	29.2	182,705	6.6
5-9	60,380	19.3	1,429,385	19.2	353,570	12.8
10-14	56,171	18.0	925,276	12.4	401,329	14.6
15-10	52,095	16.7	892,973	12.0	573,178	20.8
20+	102,367	32.7	2,039,741	27.3	1,241,969	45.1
Type of SOF member						
Operator	206,141	65.9				
Enabler	106,503	34.1				
Abbreviations: SOF, Special Operation Forces; N, number; %, percentage.						

Table G2. Sensitivity Analysis - Non-Restricted Military Service Start: Cancer Counts and Incidence Rates by Type and Study Cohort, 2001-2024

	SOF Cohort					Non-SOF Cohort					Non-SOF Deployed Cohort				
Cancer type	PY	Cases (N)	IR[a]	95% LL	95% UL	PY	Cases (N)	IR[a]	95% LL	95% UL	PY	Cases (N)	IR[a]	95% LL	95% UL
Any cancer[b]	4,497,159	7,378	164.06	160.34	167.85	88,136,560	182,603	207.18	207.17	207.19	46,479,582	91,316	196.46	195.19	197.74
Colon and rectum	4,546,903	389	8.56	7.73	9.45	89,331,701	11,350	12.71	12.47	12.94	47,078,142	5,959	12.66	12.34	12.98
Pancreas	4,548,644	85	1.87	1.49	2.31	89,390,135	3,443	3.85	3.72	3.98	47,108,538	1,672	3.55	3.38	3.72
Lung and bronchus	4,548,233	183	4.02	3.46	4.65	89,370,680	8,641	9.67	9.47	9.87	47,100,413	3,755	7.97	7.72	8.23
Bones and joints	4,548,442	75	1.65	1.30	2.07	89,388,274	1,712	1.92	1.83	2.01	47,107,510	826	1.75	1.64	1.88
Melanoma (of the skin)	4,543,524	651	14.33	13.25	15.47	89,310,059	11,026	12.35	12.12	12.58	47,063,972	5,885	12.50	12.19	12.83
Breast, female	448,024	280	62.50	55.39	70.26	15,889,617	11,077	69.71	68.42	71.02	6,119,525	4,612	75.37	73.21	77.57
Prostate	4,092,818	1,069	26.12	24.58	27.73	73,160,674	41,174	56.28	55.74	56.83	40,841,595	19,341	47.36	46.69	48.03
Testis	4,094,274	519	12.68	11.61	13.82	73,372,236	6,430	8.76	8.55	8.98	40,924,308	3,805	9.30	9.00	9.60
Urinary bladder	4,548,206	119	2.62	2.17	3.13	89,367,616	5,135	5.75	5.59	5.91	47,098,725	2,325	4.94	4.74	5.14
Kidney and renal pelvis	4,547,253	281	6.18	5.48	6.95	89,352,026	7,812	8.74	8.55	8.94	47,088,262	4,110	8.73	8.46	9.00
Brain and other nervous system	4,547,484	251	5.52	4.86	6.25	89,369,832	5,266	5.89	5.73	6.05	47,097,187	2,748	5.83	5.62	6.06
Thyroid	4,545,720	377	8.29	7.48	9.17	89,331,034	7,906	8.85	8.66	9.05	47,077,142	4,106	8.72	8.46	8.99
Non-Hodgkin lymphoma	4,546,012	387	8.51	7.69	9.40	89,331,413	9,500	10.63	10.42	10.85	47,078,013	4,832	10.26	9.98	10.56
Leukemia	4,547,166	274	6.03	5.33	6.78	89,355,946	6,874	7.69	7.51	7.88	47,091,200	3,414	7.25	7.01	7.50

Abbreviations: SOF, Special Operation Forces; PY, person-years; N, number; LL, lower limit; UL, upper limit

[a]incidence rate per 100,000 person-years

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

Table G3. Sensitivity Analysis - Non-Restricted Military Service Start: Cancer Crude and Adjusted Incidence Rate Ratio by Type and Cohort Comparison Groups, 2001-2024

	SOF vs. non-SOF cohorts				SOF vs. non-SOF deployed cohorts				SOF: Operators vs. Enablers			
Cancer type	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**	**Crude IRR**	**aIRR[a]**	**aIRR[a] 95% LL**	**aIRR[a] 95% UL**
Any cancer[b]	0.79	**1.09**	**1.06**	**1.11**	0.84	**1.10**	**1.07**	**1.12**	0.99	1.01	0.96	1.07
Colon and rectum	0.67	0.89	0.80	0.99	0.68	0.89	0.80	0.98	0.98	1.06	0.85	1.31
Pancreas	0.49	0.85	0.68	1.06	0.53	0.83	0.66	1.03	0.66	0.72	0.44	1.19
Lung and bronchus	0.42	0.90	0.78	1.05	0.50	0.91	0.79	1.06	1.09	1.24	0.90	1.69
Bones and joints	0.86	0.89	0.70	1.12	0.94	0.97	0.76	1.23	1.19	1.10	0.69	1.77
Melanoma (of the skin)	1.16	**1.22**	**1.13**	**1.33**	1.15	**1.21**	**1.11**	**1.31**	1.07	0.95	0.80	1.12
Breast, female	0.90	**1.14**	**1.01**	**1.28**	0.83	1.11	0.98	1.25	0.73	0.90	0.55	1.47
Prostate	0.46	1.05	0.98	1.11	0.55	1.06	1.00	1.13	0.81	1.00	0.88	1.15
Testis	1.45	**1.13**	**1.04**	**1.24**	1.36	**1.16**	**1.06**	**1.27**	1.12	1.02	0.85	1.21
Urinary bladder	0.46	0.83	0.69	1.00	0.53	0.82	0.68	0.98	1.28	1.15	0.80	1.67
Kidney and renal pelvis	0.71	0.95	0.84	1.07	0.71	0.95	0.84	1.07	0.85	0.85	0.65	1.10
Brain and other nervous system	0.94	0.96	0.85	1.10	0.95	1.01	0.88	1.15	1.21	1.21	0.93	1.57
Thyroid	0.94	1.02	0.91	1.13	0.95	1.03	0.93	1.15	0.94	1.10	0.87	1.37
Non-Hodgkin lymphoma	0.80	0.96	0.87	1.06	0.83	0.99	0.89	1.09	0.95	0.98	0.79	1.22
Leukemia	0.78	0.99	0.88	1.12	0.83	1.03	0.91	1.17	1.25	1.21	0.95	1.55

Abbreviations: SOF, Special Operation Forces; IRR, incidence rate ratio; aIRR, adjusted incidence rate ratio; LL, lower limit; UL, upper limit

[a]aIRR adjusted for age, sex, race/ethnicity

[b]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

Table G4. Sensitivity Analysis - Non-Restricted Military Service Start: Descriptive Statistics of Age at Diagnosis by Cancer Type and Study Cohort

	SOF Cohort				Non-SOF Cohort				Non-SOF Deployed Cohort			
Cancer type	**Min**	**Max**	**Mean[a]**	**Median[b]**	**Min**	**Max**	**Mean[a]**	**Median[b]**	**Min**	**Max**	**Mean[a]**	**Median[b]**
Any cancer[c]	18.0	78.0	44.6	45.0	17.0	89.0	51.4#	53.0#	18.0	87.0	49.3#	50.0#
Colon and rectum	21.0	76.0	45.0	45.0	17.0	85.0	50.5#	50.0#	18.0	81.0	48.4#	49.0#
Pancreas	21.0	76.0	48.4	47.0	18.0	89.0	56.6#	58.0#	19.0	80.0	53.7#	55.0^
Lung and bronchus	24.0	72.0	49.4	51.0	18.0	87.0	58.2#	60.0#	19.0	87.0	55.6#	57.0#
Bones and joints	20.0	65.0	39.3	39.0	17.0	81.0	41.5	40.0	19.0	81.0	41.7	41.0
Melanoma (of the skin)	20.0	76.0	42.1	41.0	18.0	84.0	47.9#	48.0#	18.0	81.0	45.6#	45.0#
Breast, female	22.0	69.0	44.0	43.0	19.0	84.0	48.3#	48.0#	21.0	84.0	46.7#	46.0#
Prostate	25.0	78.0	55.2	55.0	19.0	89.0	59.7#	60.0#	22.0	86.0	57.7#	58.0#
Testis	19.0	63.0	31.7	30.0	17.0	80.0	32.3	30.0	18.0	70.0	33.2#	32.0*
Urinary bladder	24.0	77.0	50.2	50.0	19.0	84.0	58.1#	60.0#	20.0	80.0	54.7#	56.0^
Kidney and renal pelvis	20.0	74.0	45.7	46.0	18.0	83.0	52.1#	53.0#	18.0	80.0	49.8#	50.0#
Brain and other nervous system	19.0	70.0	39.1	37.0	18.0	84.0	43.6#	43.0#	18.0	78.0	42.9#	42.0#
Thyroid	18.0	67.0	38.8	38.0	17.0	82.0	41.3#	40.0#	18.0	77.0	41.2#	41.0#
Non-Hodgkin lymphoma	19.0	74.0	40.2	39.0	17.0	86.0	47.5#	48.0#	18.0	83.0	45.8#	46.0#
Leukemia	19.0	74.0	42.8	42.0	17.0	87.0	48.8#	50.0#	19.0	83.0	47.1#	48.0#

Abbreviations: SOF, Special Operation Forces; Min, minimum; max, maximum.

[a]Satterthwaite t-test used to compare mean values and generate a p-value.

[b]Non-parametric Median test used to compare median values and generate a p-value.

[c]The any cancer category includes any type of cancer and not just the 14 cancers evaluated independently in this study.

*p-value <0.05

^p-value <0.01

#p-value <0.001