OFFICE OF THE UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND
READINESS

The Honorable Mike D. Rogers
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

MAY - 9 2024

Dear Mr. Chairman:

The Department's response to section 750 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021 (Public Law 116–283), "Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel," is enclosed. The Act mandated a study on the incidence of cancer diagnosis and mortality among military fixed-wing aviators (aircrew) and aviation support personnel (ground crew). Section 750(a)(2)(B) requires a report on the results of Phase 1 of the study, which determines if there is a higher incidence of cancers occurring for these military aviators and aviation support personnel as compared to similar age groups in the general population through the use of the database of the Surveillance, Epidemiology, and End Results program of the National Cancer Institute. This report concludes the Phase 1 study.

The Phase 1 study was split into Phase 1A and Phase 1B studies, due to the length of time needed to obtain data from the Department of Veterans (VA) and State cancer registries. The findings from the Phase 1A study were provided to Congress in February 2023. The findings from the Phase 1A study noted increased rates of specific cancers in aircrew and ground crew, necessitating a Phase 2 study in accordance with section 750 of the NDAA for FY 2021. However, in advance of conducting the Phase 2 study, a Phase 1B study needed to be conducted to address known gaps and limitations in the Phase 1A study related the lack of cancer data on veterans, Reserve, and National Guard members.

The Phase 1B study included data from the VA and 41 State cancer registries. It showed that aircrew members had a statistically higher incidence of cancers of all sites (by 15 percent), melanoma (by 75 percent), thyroid (by 31 percent), and prostate (by 20 percent), compared to individuals in the U.S. population. These Phase 1B findings for aircrew members are consistent with findings from the Phase 1A report.

The Phase 1B study showed ground crew members had a 12 percent higher incidence of kidney and renal pelvis cancer; however, the Phase 1B study did not show a higher incidence of cancers of brain and nervous system, thyroid, or melanoma as was seen in the Phase 1A study. The Phase 1B findings for ground crew may have differed from the Phase 1A report due to differences in the study population (e.g., inclusion of Reserve and National Guard members, exclusions based on home of record, and increased years of follow-up).

The concluding finding of the Phase 1B study suggest that aircrew and ground crew who served in the military have a higher incidence of some cancers compared to individuals in the U.S. population. It does not imply that military service in aircrew or ground crew occupations causes cancer, because multiple potential confounding factors could not be controlled for in this analysis. Differences in cancer screening rates in the military compared to the U.S. population could potentially explain the finding of increased rate of cancer diagnosis and lower mortality rates reported in Phase 1A; however, this requires further investigation.

Section 750 of the NDAA for FY 2021 states that a Phase 2 study shall be conducted if, under the Phase 1 study, an increased rate of cancers among military aircrew and ground crew is determined. Given the findings of higher incidence for some cancers among aircrew and ground crew in the Phase 1A and Phase 1B studies, the Phase 2 study is required to identify risk factors for the cancer diagnoses identified in the Phase 1 study. The Phase 2 study will likely need to be conducted in several stages over a couple of years. The start of the Phase 2 study would be expected sometime in early 2025.

Thank you for your continued strong support for the health and well-being of our Service members, veterans, and their families. I am sending similar letters to the Committee on Armed Services of the Senate and the Committees on Veterans' Affairs of the Senate and the House of Representatives.

Sincerely,

[redacted]

Ashish S. Vazirani
Performing the Duties of the Under Secretary of Defense for Personnel and Readiness

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member

[redacted]

OFFICE OF THE UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND
READINESS

MAY - 9 2024

The Honorable Jack Reed
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

The Department's response to section 750 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021 (Public Law 116–283), "Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel," is enclosed. The Act mandated a study on the incidence of cancer diagnosis and mortality among military fixed-wing aviators (aircrew) and aviation support personnel (ground crew). Section 750(a)(2)(B) requires a report on the results of Phase 1 of the study, which determines if there is a higher incidence of cancers occurring for these military aviators and aviation support personnel as compared to similar age groups in the general population through the use of the database of the Surveillance, Epidemiology, and End Results program of the National Cancer Institute. This report concludes the Phase 1 study.

The Phase 1 study was split into Phase 1A and Phase 1B studies, due to the length of time needed to obtain data from the Department of Veterans (VA) and State cancer registries. The findings from the Phase 1A study were provided to Congress in February 2023. The findings from the Phase 1A study noted increased rates of specific cancers in aircrew and ground crew, necessitating a Phase 2 study in accordance with section 750 of the NDAA for FY 2021. However, in advance of conducting the Phase 2 study, a Phase 1B study needed to be conducted to address known gaps and limitations in the Phase 1A study related the lack of cancer data on veterans, Reserve, and National Guard members.

The Phase 1B study included data from the VA and 41 State cancer registries. It showed that aircrew members had a statistically higher incidence of cancers of all sites (by 15 percent), melanoma (by 75 percent), thyroid (by 31 percent), and prostate (by 20 percent), compared to individuals in the U.S. population. These Phase 1B findings for aircrew members are consistent with findings from the Phase 1A report.

The Phase 1B study showed ground crew members had a 12 percent higher incidence of kidney and renal pelvis cancer; however, the Phase 1B study did not show a higher incidence of cancers of brain and nervous system, thyroid, or melanoma as was seen in the Phase 1A study. The Phase 1B findings for ground crew may have differed from the Phase 1A report due to differences in the study population (e.g., inclusion of Reserve and National Guard members, exclusions based on home of record, and increased years of follow-up).

The concluding finding of the Phase 1B study suggest that aircrew and ground crew who served in the military have a higher incidence of some cancers compared to individuals in the U.S. population. It does not imply that military service in aircrew or ground crew occupations causes cancer, because multiple potential confounding factors could not be controlled for in this analysis. Differences in cancer screening rates in the military compared to the U.S. population could potentially explain the finding of increased rate of cancer diagnosis and lower mortality rates reported in Phase 1A; however, this requires further investigation.

Section 750 of the NDAA for FY 2021 states that a Phase 2 study shall be conducted if, under the Phase 1 study, an increased rate of cancers among military aircrew and ground crew is determined. Given the findings of higher incidence for some cancers among aircrew and ground crew in the Phase 1A and Phase 1B studies, the Phase 2 study is required to identify risk factors for the cancer diagnoses identified in the Phase 1 study. The Phase 2 study will likely need to be conducted in several stages over a couple of years. The start of the Phase 2 study would be expected sometime in early 2025.

Thank you for your continued strong support for the health and well-being of our Service members, veterans, and their families. I am sending similar letters to the Committee on Armed Services of the House of Representatives and the Committees on Veterans' Affairs of the Senate and the House of Representatives.

Sincerely,

[redacted]

Ashish S. Vazirani
Performing the Duties of the Under Secretary of Defense for Personnel and Readiness

Enclosure:
As stated

cc:
The Honorable Roger F. Wicker
Ranking Member

[redacted]

OFFICE OF THE UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND
READINESS

The Honorable Jon Tester
Chairman
Committee on Veterans' Affairs
United States Senate
Washington, DC 20510

MAY - 9 2024

Dear Mr. Chairman:

The Department's response to section 750 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021 (Public Law 116–283), "Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel," is enclosed. The Act mandated a study on the incidence of cancer diagnosis and mortality among military fixed-wing aviators (aircrew) and aviation support personnel (ground crew). Section 750(a)(2)(B) requires a report on the results of Phase 1 of the study, which determines if there is a higher incidence of cancers occurring for these military aviators and aviation support personnel as compared to similar age groups in the general population through the use of the database of the Surveillance, Epidemiology, and End Results program of the National Cancer Institute. This report concludes the Phase 1 study.

The Phase 1 study was split into Phase 1A and Phase 1B studies, due to the length of time needed to obtain data from the Department of Veterans (VA) and State cancer registries. The findings from the Phase 1A study were provided to Congress in February 2023. The findings from the Phase 1A study noted increased rates of specific cancers in aircrew and ground crew, necessitating a Phase 2 study in accordance with section 750 of the NDAA for FY 2021. However, in advance of conducting the Phase 2 study, a Phase 1B study needed to be conducted to address known gaps and limitations in the Phase 1A study related the lack of cancer data on veterans, Reserve, and National Guard members.

The Phase 1B study included data from the VA and 41 State cancer registries. It showed that aircrew members had a statistically higher incidence of cancers of all sites (by 15 percent), melanoma (by 75 percent), thyroid (by 31 percent), and prostate (by 20 percent), compared to individuals in the U.S. population. These Phase 1B findings for aircrew members are consistent with findings from the Phase 1A report.

The Phase 1B study showed ground crew members had a 12 percent higher incidence of kidney and renal pelvis cancer; however, the Phase 1B study did not show a higher incidence of cancers of brain and nervous system, thyroid, or melanoma as was seen in the Phase 1A study. The Phase 1B findings for ground crew may have differed from the Phase 1A report due to differences in the study population (e.g., inclusion of Reserve and National Guard members, exclusions based on home of record, and increased years of follow-up).

The concluding finding of the Phase 1B study suggest that aircrew and ground crew who served in the military have a higher incidence of some cancers compared to individuals in the U.S. population. It does not imply that military service in aircrew or ground crew occupations causes cancer, because multiple potential confounding factors could not be controlled for in this analysis. Differences in cancer screening rates in the military compared to the U.S. population could potentially explain the finding of increased rate of cancer diagnosis and lower mortality rates reported in Phase 1A; however, this requires further investigation.

Section 750 of the NDAA for FY 2021 states that a Phase 2 study shall be conducted if, under the Phase 1 study, an increased rate of cancers among military aircrew and ground crew is determined. Given the findings of higher incidence for some cancers among aircrew and ground crew in the Phase 1A and Phase 1B studies, the Phase 2 study is required to identify risk factors for the cancer diagnoses identified in the Phase 1 study. The Phase 2 study will likely need to be conducted in several stages over a couple of years. The start of the Phase 2 study would be expected sometime in early 2025.

Thank you for your continued strong support for the health and well-being of our Service members, veterans, and their families. I am sending similar letters to the Committee on Veterans' Affairs of the House of Representatives and the Committees on Armed Services of the Senate and the House of Representatives.

Sincerely,

[redacted]

Ashish S. Vazirani
Performing the Duties of the Under Secretary of Defense for Personnel and Readiness

Enclosure:
As stated

cc:
The Honorable Jerry Moran
Ranking Member

[redacted]

OFFICE OF THE UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND
READINESS

The Honorable Mike Bost
Chairman
Committee on Veterans' Affairs
U.S. House of Representatives
Washington, DC 20515

MAY - 9 2024

Dear Mr. Chairman:

The Department's response to section 750 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021 (Public Law 116–283), "Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel," is enclosed. The Act mandated a study on the incidence of cancer diagnosis and mortality among military fixed-wing aviators (aircrew) and aviation support personnel (ground crew). Section 750(a)(2)(B) requires a report on the results of Phase 1 of the study, which determines if there is a higher incidence of cancers occurring for these military aviators and aviation support personnel as compared to similar age groups in the general population through the use of the database of the Surveillance, Epidemiology, and End Results program of the National Cancer Institute. This report concludes the Phase 1 study.

The Phase 1 study was split into Phase 1A and Phase 1B studies, due to the length of time needed to obtain data from the Department of Veterans (VA) and State cancer registries. The findings from the Phase 1A study were provided to Congress in February 2023. The findings from the Phase 1A study noted increased rates of specific cancers in aircrew and ground crew, necessitating a Phase 2 study in accordance with section 750 of the NDAA for FY 2021. However, in advance of conducting the Phase 2 study, a Phase 1B study needed to be conducted to address known gaps and limitations in the Phase 1A study related the lack of cancer data on veterans, Reserve, and National Guard members.

The Phase 1B study included data from the VA and 41 State cancer registries. It showed that aircrew members had a statistically higher incidence of cancers of all sites (by 15 percent), melanoma (by 75 percent), thyroid (by 31 percent), and prostate (by 20 percent), compared to individuals in the U.S. population. These Phase 1B findings for aircrew members are consistent with findings from the Phase 1A report.

The Phase 1B study showed ground crew members had a 12 percent higher incidence of kidney and renal pelvis cancer; however, the Phase 1B study did not show a higher incidence of cancers of brain and nervous system, thyroid, or melanoma as was seen in the Phase 1A study. The Phase 1B findings for ground crew may have differed from the Phase 1A report due to differences in the study population (e.g., inclusion of Reserve and National Guard members, exclusions based on home of record, and increased years of follow-up).

The concluding finding of the Phase 1B study suggest that aircrew and ground crew who served in the military have a higher incidence of some cancers compared to individuals in the U.S. population. It does not imply that military service in aircrew or ground crew occupations causes cancer, because multiple potential confounding factors could not be controlled for in this analysis. Differences in cancer screening rates in the military compared to the U.S. population could potentially explain the finding of increased rate of cancer diagnosis and lower mortality rates reported in Phase 1A; however, this requires further investigation.

Section 750 of the NDAA for FY 2021 states that a Phase 2 study shall be conducted if, under the Phase 1 study, an increased rate of cancers among military aircrew and ground crew is determined. Given the findings of higher incidence for some cancers among aircrew and ground crew in the Phase 1A and Phase 1B studies, the Phase 2 study is required to identify risk factors for the cancer diagnoses identified in the Phase 1 study. The Phase 2 study will likely need to be conducted in several stages over a couple of years. The start of the Phase 2 study would be expected sometime in early 2025.

Thank you for your continued strong support for the health and well-being of our Service members, veterans, and their families. I am sending similar letters to the Committee on Veterans' Affairs of the Senate and the Committees on Armed Services of the Senate and the House of Representatives.

Sincerely,

[redacted]

Ashish S. Vazirani
Performing the Duties of the Under Secretary of Defense for Personnel and Readiness

Enclosure:
As stated

cc:
The Honorable Mark Takano
Ranking Member

[redacted]

Report to the Committees on Armed Services of the Senate and the House of Representatives and the Committees on Veterans' Affairs of the Senate and the House of Representatives

Study on the Incidence of Cancer Diagnosis and Mortality Among Military Aviators and Aviation Support Personnel: Phase 1B

May 2024

The estimated cost of this report or study for the Department of Defense is approximately $118,500 in Fiscal Years 2022 - 2024. This includes $15,500 in expenses and $103,000 in DoD labor.

TABLE OF CONTENTS

1 Executive Summary

Introduction

This report is in response to section 750 of the William M. (Mac) Thornberry National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2021 (Public Law 116–283), "Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel." The Act mandated a study on the incidence of cancer diagnosis and mortality among military fixed wing aviators (aircrew) and aviation support personnel (ground crew). The findings from the Phase 1A report were released in February 2023. The Phase 1A study and report had known gaps and limitations related the lack of cancer data on veterans, and Reserve and National Guard members. To address these gaps, a supplementary Phase 1B study was conducted which included data from the Department of Veterans Affairs (VA) and 41 State cancer registries. This report presents the findings from the Phase 1B study. The findings and implications for the Phase 2 study are provided below.

Background

- Section 750 of the NDAA for FY 2021 required a two-phase study strategy.

- Phase 1 requires an epidemiologic study to determine if there is a higher incidence of cancers occurring for military aircrew and ground crew as compared to the U.S. population using the Surveillance, Epidemiology, and End Results (SEER) program database, after adjusting for age, sex, and race.

- Due to time constraints, data from the VA and State cancer registries were not available by the due date of the Phase 1 study, so Phase 1 was split into Phase 1A and Phase 1B. Only Department of Defense (DoD) cancer registry and Tricare claims data were used to assess cancer incidence in the Phase 1A report. This Phase 1B report is intended to bridge the data gap for all military Components and veterans to provide a complete and final cancer incidence analysis for Phase 1.

- Phase 1A findings indicated that Active Component aircrew members had higher incidence of melanoma (by 87 percent), thyroid (by 39 percent), and prostate (by 16 percent) cancers compared to demographically similar U.S. population in SEER.

- Phase 1A indicated that Active Component ground crew members had higher rates of cancers of brain and nervous system (by 19 percent), thyroid (by 15 percent), melanoma (by 9 percent), and kidney and renal pelvis (by 9 percent) cancers compared to demographically similar U.S. population in SEER.

- Phase 1A findings also indicated that aircrew and ground crew in the Active Component had a respective 24 percent and 3 percent higher incidence of cancer for all sites compared to a demographically similar U.S. population in SEER.

- Phase 1A findings however indicated that aircrew and ground crew in Active and

Reserve Components had a 56 percent and 35 percent lower mortality rate, respectively, for all cancer sites compared to the demographically similar U.S. population in SEER.

- The Phase 1B study used the same malignant cancers that were evaluated in the Phase 1A study.

- Section 750 of the NDAA for FY 2021 requires a Phase 2 study if, under Phase 1, there is an increased rate of cancers or cancer mortality among military aircrew or ground crew. Phase 1A results require Phase 2 follow-up.

Results

- There were 138,505 aircrew and 659,985 ground crew in the Phase 1B study. This included both Active and Reserve Components representing all military branches. Phase 1B identified cancers diagnosed between 1992 and 2017.

- Most military members in both occupation groups were male, non-Hispanic White, Active Component, and of enlisted rank at entry into the study. Aircrew had a higher proportion of officers compared to ground crew.

- The median age at diagnosis for malignant cancer of all sites was 55 years in aircrew and 54 years in ground crew. In contrast, the median age at diagnosis for malignant cancer of all sites was 67 years in the SEER reference population. Most of the aircrew group consisted of members from the Air Force (72.1 percent) and Navy (20.2 percent). The ground crew group also consisted mostly of members from the Air Force (48.9 percent) and Navy (37.0 percent).

- The majority of the aircrew group consisted of members from the Air Force (72.1 percent) and Navy (20.2 percent). The ground crew group also consisted mostly of members from the Air Force (48.9 percent) and Navy (37.0 percent).

- Compared to a demographically similar U.S. population in SEER, aircrew had a 75 percent higher rate of melanoma, 31 percent higher rate of thyroid cancer, 20 percent higher rate of prostate cancer, and a 15 percent higher rate of cancer for all sites combined.

- Ground crew members had a 12 percent higher rate of kidney and renal pelvis cancer but a 5 percent lower rate of all sites combined, compared to the demographically similar U.S. population in SEER.

Discussion

- The inclusion of VA and State cancer registry data in the Phase 1B study allowed the cancer incident analysis to include Reserve and National Guard members who were excluded from the Phase 1A analysis.

- The findings of higher rates of melanoma, prostate, and thyroid cancer among aircrew is consistent with findings from the Phase 1A report.

- Findings for ground crew may have differed from the Phase 1A report due to differences in the study population (e.g., inclusion of Reserve and Guard members, exclusions based on home of record, and increased years of follow-up). However, both kidney and renal pelvis as well as thyroid cancers were elevated among Active Component ground crew in both Phase 1A and Phase 1B.

- Findings of increased cancer incidence do not imply that military service in aircrew or ground crew occupations causes cancer. For example, higher incidence findings could be attributed to higher screening rates in the military population.

- Due to the features of cancer registry and medical claims data, data are not available on family history of cancer, smoking, diet, and other lifestyle factors, which may confound the comparison of cancer incidence between the military and U.S. population.

- The military study population was relatively young compared to the U.S. population. Results may have differed if additional older former Service members had been included in the study, since cancer risk increases with age.

Recommendations

- Phase 1 findings of increased rates of specific cancers in aircrew and ground crew necessitates a Phase 2 study in accordance with section 750 of the NDAA for FY 2021.

- A phase 2 study is recommended to investigate and identify the potential specific occupational and environmental risk factors that may be associated with the increased risk of the cancers identified in the Phase 1A and 1B studies.

- Increased incidence rates of certain cancers should be interpreted in the context of lower mortality rates for all cancer sites compared to the demographically similar U.S. population.

- Future studies should include cancer staging data and cancer screening rates to better understand the increased risk of cancers identified in this study.

2 Purpose of Report – The Section 750 of the NDAA for FY 2021 Tasking

2.1 Department of Defense Response

For Phase 1, a task force was assembled to conduct the requested study under the oversight of the Defense Health Agency (DHA) and Office of the Deputy Assistant Secretary of Defense for Health Readiness Policy and Oversight within the Office of the Assistant Secretary of Defense

for Health Affairs. Representatives from the Service branches, the Armed Forces Health Surveillance Division (AFHSD), National Cancer Institute (NCI), North American Association of Central Cancer Registries (NAACCR), Uniformed Services University of the Health Sciences, and the Murtha Cancer Center were included in an initial formative meeting. The task force established smaller working groups to identify appropriate military data sources, to identify the military study population, and to conduct the analyses for the report.

2.2 Study Strategy

To answer the questions posed by the section 750 of the NDAA for FY 2021 requirement, a two-phase study strategy was mandated:

Phase 1A: Conduct an epidemiologic study using DoD data to determine if there is a higher incidence of cancers and cancer deaths occurring among fixed-wing aviators, hereafter referred to as "aircrew", and aviation support personnel, hereafter referred to as "ground crew," compared to the U.S. population using the SEER database after adjusting for age, sex, and race. This phase was led by AFHSD and assisted by NCI, NAACCR, and Service representatives.

Phase 1B: Conduct an epidemiologic study using data from the VA and State cancer registries to determine if there is a higher incidence of cancers occurring among aircrew and ground crew. This phase will afford greater capture of cancer diagnoses in former military members, and those who serve in the National Guard and Reserve branches.

Phase 2: Phase 2 will be conducted if, under Phase 1, there is determined to be an increased rate of cancer or cancer mortality among military aircrew and ground crew. Phase 2 will consist of identifying the carcinogenic toxicants or hazardous materials associated with military flight operations; identifying operating environments that could be associated with increased amounts of ionizing and nonionizing radiation; identifying specific duties, dates of service, and types of aircraft flown that could have increased the risk for cancer; identifying duty locations associated with higher incidence of cancers; identifying potential exposures due to military service that are not related to aviation; and determining the appropriate age to begin screening military aircrew and ground crew for cancers.

3 Report of Phase 1B Study of Cancer Incidence

3.1 Background: Phase 1A Cancer Incidence and Mortality

The objective of the Phase 1 study is to determine whether there is a higher incidence of cancer diagnosis or mortality among aircrew or ground crew, compared to similar age, sex, and race groups in the U.S. population using the NCI's SEER database. The study protocol for Phase 1 was approved and determined to be "Not Research" by the DHA Office of Human Research Protections on July 27, 2021.

Phase 1 was divided into two phases: Phase 1A and Phase 1B. This was done because of the amount of time required to retrieve cancer data from Service members from data systems outside of the DoD (e.g., VA and State cancer registries). The Phase 1A cancer incidence analysis

included cancer data from the DoD cancer registry and administrative healthcare claims. The Phase 1A study also included an analysis of cancer mortality rates among aircrew and ground crew compared to the U.S. population and found that mortality for all cancer sites was lower among aircrew and ground crew compared to the U.S. population [1].

Phase 1B was conducted to update the cancer incidence analysis of Phase 1A by including additional cancer data from the VA Central Cancer Registry and the U.S. State cancer registries. The inclusion of these two data sources provides better ascertainment of cancer cases for veterans, Reserve and National Guard members, and others without access to TRICARE coverage.

3.2 Methods

3.2.1 Data Sources

Personnel records were obtained from the Defense Manpower Data Center demographic records maintained in the Defense Medical Surveillance System (DMSS) at the AFHSD. DMSS includes occupational records of all members of the Navy, Air Force, and Marine Corps serving in the Active and Reserve Components of the Armed Forces dating back to 1990 and for Army Active and Reserve Components dating back to 1985.

SEER is the authoritative source for cancer incidence and mortality statistics for the United States, and individuals in this database served as the reference group in the study. The SEER incidence data date back to 1975 and were complete through the end of 2018 at the time of data collection. However, records did not become standardized using Hispanic and non-Hispanic race/ethnicity categories until 1992.

Cancer cases for the military cohort were identified using data from the Virtual Pooled Registry Cancer Linkage System (VPR-CLS), the VA Central Cancer Registry (VACCR), the DoD's cancer registry system Oncolog, formerly known as the Automated Central Tumor Registry, and the DMSS. Oncolog includes cancer data reported by military medical treatment facilities on all DoD beneficiaries, including active duty military personnel, retired military personnel, and Reserve and National Guard personnel diagnosed while on active duty. These data date back to the mid-1980s but are not considered complete until 1990. At the time of data collection for this study, Oncolog data were complete through the end of 2017. Cancer cases for the military cohort were also identified from the DMSS, which includes inpatient and outpatient administrative (i.e., billing) data for cancer diagnoses that occurred in direct care (i.e., in a military medical treatment facility) and outsourced care (when reimbursed by TRICARE).

3.2.2 Study Population

Current and former aircrew and ground crew personnel were identified using duty military occupation specialty codes (DMOS) in DMSS. Individuals were included in the study population if they had an occupation code listed in DMSS. This differed from Phase 1A study inclusion criteria, which had also required individuals to be in military service or have an inpatient or outpatient medical encounter at a military treatment facility between 1992 and 2017.

Because of high coverage rates of the State cancer registries included in the VPR-CLS, it was assumed that if any of the individuals in the military study population were diagnosed with cancer, it would be likely to be picked up via one of the included data sources [2]. However, not all States are represented in this analysis. At the time of the study, Minnesota, Vermont, South Dakota, Kansas, Nevada, and Washington, D.C., were not participating in the VPR-CLS. In addition, cancer registry data for Washington State did not include regions outside of Seattle/Puget Sound. Mississippi, Missouri, Texas, and Nebraska participated in the VPR-CLS but were excluded because they did not provide data prior to the deadline for this report. To adjust for potential bias due to these missing data, aircrew and ground crew were excluded from the Phase 1B analysis if they had a home of record listed in DMSS for any of the aforementioned States (not including Seattle, WA), as well as Washington, D.C.

The same method to identify aircrew and ground crew from Phase 1A was used in Phase 1B. The DMOS codes used to identify aircrew and ground crew were selected by Service representatives and subject matter experts. DMOS records specific to remotely piloted aircraft, helicopters or tiltrotor aircraft were excluded. Because not all Navy DMOS codes distinguished between fixed-wing and helicopter aircrew occupations, Navy DMOS records that occurred in tandem with a Unit Identification Code pertaining to helicopter squadrons were also excluded.

Individuals who spent at least 3 years of military service in an aircrew occupation (does not include training time) were classified as aircrew. The remaining individuals were then classified according to the occupation category for which they spent the greatest amount of time during military service, from the time that personnel data became available in DMSS through the end of the study period. For example, if an individual spent 2 years in aircrew occupations, 1.5 years in ground crew occupations, and 1 year in other occupations, they were classified as aircrew. This categorization was determined by subject matter experts to be the best method for identifying enough aircrew members within reason, after inspection of the data and in the absence of information on flight hours. The methodology also draws from the "usual occupation" approach used by the National Institute for Occupational Safety and Health for occupational epidemiology, which was used in a previous study of malignancy in U.S. Air Force fighter pilots [3].

3.2.3 Outcomes

Phase 1B evaluated the same surveillance period and cancer types as in Phase 1A. January 1, 1992 was selected as the start date of follow-up for the study and is the date that the SEER database began using standardized race/ethnicity categories, which was necessary for the analysis. December 31, 2017 was selected as the study period end date because it is the period through which Oncolog tumor registry data were considered complete at the time of the Phase 1A analysis.

All types of malignant cancer diagnoses were included in this study. However, the following 12 cancers were also analyzed separately: colon and rectum, pancreas, melanoma, prostate, testis, urinary bladder, kidney and renal pelvis, brain and other nervous system, thyroid, non-Hodgkin lymphoma, female breast, and lung and bronchus. These cancers were selected based on concern from veteran advocacy groups and prior cancer studies that demonstrated increased incidence in military populations. All cancer registry cases were categorized according to SEER site recoding

instructions available at: https://seer.cancer.gov/siterecode/icdo3_dwhoheme/index.html.

Inpatient data are available in DMSS from 1990 and outpatient data are available from 1996. Administrative data case-finding algorithms were used to identify incident cancer cases in the DMSS data [4]. The same cases identified using DMSS data in the Phase 1A study were used in Phase 1B. The list of qualifying International Classifications of Diseases (ICD), 9th and 10th edition (ICD-9 and ICD-10) diagnoses by cancer type can be found in Appendix B of the Phase 1A report [1].

3.2.4 Analysis

For all analyses, cancer cases and person-time in the military study population was assigned to unique combinations (called "stratum") for race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, and Other), sex (male, female), and age group category (5-year intervals). Person-time differed for each of the 12 cancer types. The beginning of follow-up was defined as the earliest date of military service or January 1, 1992, whichever came first. The end of follow-up was defined as the earliest of the following: 1) the end of study period on December 31, 2017; 2) death due to any cause; or 3) the first cancer diagnosis for that specific cancer. Person-time was calculated as the number of person-years between the beginning and end of follow-up.

NCI investigators calculated the observed number of U.S. population cases and population sizes for each stratum using SEER. SEER uses mid-year population estimates as a proxy for the person-time at risk in the calendar year, and multiple tumors may be counted as cases in the numerator. The number of expected cases is the cases that would be expected to occur in the military cohort had they experienced the same age, sex, and race stratum-specific risks of the U.S. population. The number of expected cases was calculated by AFHSD using the SEER stratum-specific rates, and this expected number of cases was compared to the number of observed cases for the military cohort. This analysis comparing observed to expected number of cases was performed separately for aircrew and ground crew.

Standardized incidence ratios (SIRs) were calculated as the number of observed over the number of expected incident cancer cases (see Appendix B). These ratios were calculated separately for malignant cancer of all sites, for each of the 12 specific cancers, and separately for aircrew and ground crew. In addition, 95 percent confidence intervals and p-values were generated using a Poisson distribution. All statistical analyses were performed using SAS® Enterprise Guide® software (Version 8.3, SAS Inst, Inc., Cary, NC).

3.3 Results

3.3.1 Introduction

This section describes the military study population, and then presents the results of the cancer incidence analysis. For each subsection, the findings are presented for all Components (Active, and Reserve) combined. The results are then presented separately for Active and Reserve Components.

3.3.2 Description of Military Study Population

There were 138,505 aircrew and 659,825 ground crew included in the military cohort, which included both Active and Reserve Component members (Table 1). Because individuals were excluded if they had a home of record listed for one of the State cancer registries whose data was missing, this study population was slightly smaller than the population assessed in Phase 1A. Follow-up time varied depending on the analysis being conducted (see person years in Tables 2-7). Service members in both aircrew and ground crew were predominantly male and non-Hispanic White, Active Component, aged 29 or less at entry into the study, and of enlisted rank at entry. However, aircrew had a higher proportion of officers compared to ground crew, with 48.0 percent enlisted and 51.3 percent officers. The majority of the aircrew group consisted of members from the Air Force (72.2 percent), followed by the Navy (20.2 percent). The ground crew group also consisted mostly of members from the Air Force (48.9 percent) and Navy (37.0 percent). More than one-half (56.0 percent, n=77,530) of the aircrew group and more than one-third (38.7 percent, n=255,242) of the ground crew group consisted of individuals who joined military service prior to 1990. A small proportion of aircrew (4.4 percent, n=6,150) and ground crew (3.7 percent, n=24,266) joined military service in the 1960s or earlier.

3.3.3 Age at Follow-up and at Diagnosis

The median age at the end of follow-up for malignant cancer of all sites was 49 years for aircrew and 43 years for ground crew. The median age at diagnosis for malignant cancer of all sites was 55 years in aircrew and 54 years in ground crew. In contrast, the median age at diagnosis for malignant cancer of all sites was 67 years in the SEER reference population.

Table 1. Demographics of the military study cohort used in Phase 1B

	Aircrew		Ground crew	
	N	%	N	%
Total study population	138,505	100	659,825	100
Age (years)[a]				
29 or less	90,181	65.1	517,245	78.4
30-49	47,182	34.1	135,301	20.5
50+	1,142	0.80	7,279	1.1
Sex				
Male	129,692	93.6	595,432	90.2
Female	8,813	6.4	64,393	9.8
Race/ethnicity				
Non-Hispanic White	120,324	86.9	479,329	72.6
Non-Hispanic Black	6,184	4.5	83,820	12.7
Hispanic	6,408	4.6	53,863	8.2
Non-Hispanic Other	5,589	4.0	42,813	6.5
Service[a]				
Army	3,322	2.4	40,677	6.2
Navy	27,914	20.2	244,135	37.0
Air Force	99,942	72.2	322,395	48.9
Marine Corps	7,327	5.3	52,618	8.0
Component				
Active	95,552	69.0	488,814	74.1
Reserve/National Guard[b]	42,953	31.0	171,011	25.9
Rank[a]				
Enlisted	66,458	48.0	644,289	97.7
Officer	71,061	51.3	12,511	1.9
Missing/ unknown	986	0.7	3,025	0.5
Year at entry into military service				
1940-1949	10	0.0	63	0.0
1950-1959	377	0.3	2,818	0.4
1960-1969	5,763	4.2	21,385	3.2
1970-1979	26,930	19.4	74,814	11.3
1980-1989	44,450	32.1	156,162	23.7
1990-1999	26,536	19.2	155,933	23.6
2000-2009	25,822	18.6	144,493	21.9
2010-2017	8,140	5.9	95,888	14.5
Missing/unknown[c]	477	0.3	8,269	1.3

[a]Age, service branch, and rank were measured at the beginning of follow-up.
[b]Defined as having served in the Reserves or National Guard prior to the end of the study period.
[c]Year at entry was defined as missing/unknown for individuals aged <17 years or > 45 years at the date of entry into military service, as these were assumed to be data entry errors.

3.3.4 Cancer Incidence: Military Compared to U.S. Population

All Components

There was a total of 4,639,667 malignant cancer cases observed in SEER during the study period. In the military cohort, there were 10,489 malignant cancer cases among aircrew and 29,415 among ground crew.

After adjusting for age, sex, and race/ethnicity, aircrew members had statistically higher incidence of cancers of all sites (by 15 percent), melanoma (by 75 percent), thyroid (by 31 percent), and prostate (by 20 percent), compared to individuals in the U.S. population (Table 2). Incidence of cancers of the colon and rectum, urinary bladder, kidney and renal pelvis, pancreas, and lung and bronchus were statistically lower compared to individuals in the U.S. population by 38 percent, 30 percent, 17 percent, 17 percent, and 63 percent, respectively. There was not a statistically significant difference between aircrew members and members of the U.S. population for cancers of the testis, brain and nervous system, non-Hodgkin lymphoma, and female breast.

Table 2. Observed and expected cancer cases, aircrew compared to U.S. population, 1992-2017

Cancer site	Person-years[a]	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	2,832,855	10,489	9,158	1.15	1.12	1.17	<.0001
Colon and rectum	2,908,259	557	898	0.62	0.57	0.67	<.0001
Pancreas	2,911,547	173	209	0.83	0.71	0.96	0.0122
Melanoma	2,899,634	1,334	764	1.75	1.65	1.84	<.0001
Prostate	2,741,047	2,784	2,320	1.20	1.16	1.25	<.0001
Testis	2,755,683	279	297	0.94	0.83	1.06	0.3133
Urinary bladder	2,909,535	341	484	0.70	0.63	0.78	<.0001
Kidney and renal pelvis	2,909,789	337	407	0.83	0.74	0.92	0.0004
Brain and nervous system	2,910,843	211	214	0.99	0.86	1.13	0.8958
Thyroid	2,908,854	303	232	1.31	1.16	1.46	<.0001
Non-Hodgkin lymphoma	2,908,216	492	535	0.92	0.84	1.01	0.0649
Female breast	150,614	137	123	1.11	0.94	1.32	0.2225
Lung and bronchus	2,910,816	368	1,006	0.37	0.33	0.41	<.0001

[a]Person-year totals do not equal the sum of tables 4 and 6 due to rounding to the nearest person-year in the aggregated output.

Ground crew members had statistically higher incidence of kidney and renal pelvis cancer (by 12 percent), compared to individuals in the U.S. population (Table 3). Ground crew members had statistically lower incidence of cancers of the colon and rectum (by 22 percent), pancreas (by 10 percent), melanoma (by 4 percent), testis (by 14 percent), non-Hodgkin lymphoma (by 18 percent), female breast (by 8 percent), lung and bronchus (by 26 percent), and all sites (by 5 percent). There was no statistically significant difference for cancers of the prostate, urinary bladder, brain and nervous system, and thyroid.

Table 3. Observed and expected cancer cases, ground crew compared to U.S. population, 1992-2017

Cancer site	Person-years[a]	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	12,275,116	29,415	30,921	0.95	0.94	0.96	<0.0001
Colon and rectum	12,463,406	2,289	2,928	0.78	0.75	0.81	<0.0001
Pancreas	12,476,844	600	667	0.90	0.83	0.98	0.0094
Melanoma	12,458,919	2,252	2,351	0.96	0.92	1.00	0.0416
Prostate	11,361,610	7,105	7,048	1.01	0.98	1.03	0.5028
Testis	11,396,474	1,046	1,211	0.86	0.81	0.92	<0.0001
Urinary bladder	12,468,845	1,363	1,415	0.96	0.91	1.02	0.1725
Kidney and renal pelvis	12,469,221	1,474	1,314	1.12	1.06	1.18	<0.0001
Brain and nervous system	12,474,084	716	741	0.97	0.90	1.04	0.3765
Thyroid	12,469,737	892	874	1.02	0.96	1.09	0.543
Non-Hodgkin lymphoma	12,466,542	1,500	1,832	0.82	0.78	0.86	<0.0001
Female breast	1,061,428	763	826	0.92	0.86	0.99	0.0281
Lung and bronchus	12,472,065	2,361	3,197	0.74	0.71	0.77	<0.0001

[a]Person-year totals do not equal the sum of tables 5 and 7 due to rounding to the nearest person-year in the aggregated output.

Active Component

There were 7,598 malignant cancer cases among Active Component aircrew and 18,904 among Active Component ground crew. After adjusting for age, sex, and race/ethnicity, Active Component aircrew members had statistically higher incidence of cancers of all sites (by 20 percent), melanoma (by 80 percent), thyroid (by 38 percent), and prostate (by 21 percent), compared to individuals in the U.S. population (Table 4). Incidence of cancers of the colon and rectum, urinary bladder, kidney and renal pelvis, and lung and bronchus were statistically lower compared to individuals in the U.S. population by 41 percent, 29 percent, 13 percent, 17 percent, and 64 percent, respectively. There was not a statistically significant difference between Active Component aircrew members and members of the U.S. population for cancers of the pancreas, testis, brain and nervous system, non-Hodgkin lymphoma, and female breast.

Table 4. Observed and expected cancer cases, Active Component aircrew compared to U.S. population, 1992-2017

Cancer site	Person-years	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	1,894,894	7,598	6,320	1.20	1.18	1.23	<0.0001
Colon and rectum	1,950,944	368	621	0.59	0.53	0.66	<0.0001
Pancreas	1,953,139	127	145	0.87	0.73	1.04	0.1315
Melanoma	1,944,409	941	522	1.80	1.69	1.92	<0.0001
Prostate	1,846,208	1,999	1,650	1.21	1.16	1.27	<0.0001
Testis	1,856,369	201	196	1.02	0.89	1.18	0.7495
Urinary bladder	1,951,766	238	335	0.71	0.62	0.81	<0.0001
Kidney and renal pelvis	1,951,766	247	283	0.87	0.77	0.99	0.0312

Brain and nervous system	1,952,614	150	146	1.03	0.87	1.21	0.7415
Thyroid	1,951,070	214	155	1.38	1.20	1.57	<0.0001
Non-Hodgkin lymphoma	1,950,690	354	366	0.97	0.87	1.07	0.5484
Female breast	92,935	84	71	1.18	0.94	1.46	0.1531
Lung and bronchus	1,952,592	255	702	0.36	0.32	0.41	<0.0001

Active Component ground crew members had statistically higher incidence of kidney and renal pelvis (by 21 percent) and thyroid (by 9 percent) cancers, compared to individuals in the U.S. population (Table 5). Active Component ground crew members had statistically lower incidence of cancers of the colon and rectum (by 18 percent), testis (by 9 percent), non-Hodgkin lymphoma (by 15 percent), and lung and bronchus (by 19 percent). There was no statistically significant difference for cancers of the pancreas, melanoma, prostate, urinary bladder, brain and nervous system, female breast, and all sites combined.

Table 5. Observed and expected cancer cases, Active Component ground crew compared to U.S. population, 1992-2017

Cancer site	Person-years	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	8,832,481	18,904	19,011	0.99	0.98	1.01	0.4394
Colon and rectum	8,953,820	1,438	1,764	0.82	0.77	0.86	<0.0001
Pancreas	8,962,017	383	387	0.99	0.89	1.09	0.8532
Melanoma	8,950,374	1,461	1,506	0.97	0.92	1.02	0.2531
Prostate	8,157,874	3,974	3,961	1.00	0.97	1.03	0.8394
Testis	8,171,554	805	886	0.91	0.85	0.97	0.0059
Urinary bladder	8,957,452	798	776	1.03	0.96	1.10	0.4357
Kidney and renal pelvis	8,957,025	989	816	1.21	1.14	1.29	<0.0001
Brain and nervous system	8,959,862	510	495	1.03	0.94	1.12	0.5112
Thyroid	8,956,648	654	600	1.09	1.01	1.18	0.0302
Non-Hodgkin lymphoma	8,954,923	1,000	1,177	0.85	0.80	0.90	<0.0001
Female breast	776,437	495	520	0.95	0.87	1.04	0.2859
Lung and bronchus	8,959,092	1,440	1,788	0.81	0.76	0.85	<0.0001

Reserve Component

There were 2,891 malignant cancer cases among Reserve and Guard Component aircrew and 10,511 among Reserve Component ground crew. After adjusting for age, sex, and race/ethnicity, Reserve Component aircrew members had statistically higher incidence of cancers of melanoma (by 62 percent) and prostate (by 17 percent), compared to individuals in the U.S. population (Table 6). Incidence of cancers of the colon and rectum, pancreas, testis, urinary bladder, kidney and renal pelvis, non-Hodgkin lymphoma, lung and bronchus were statistically lower compared to individuals in the U.S. population by 32 percent, 27 percent, 23 percent, 31 percent, 27 percent, 18 percent, and 63 percent, respectively. There was not a statistically significant difference between Reserve and Guard Component aircrew members and members of the U.S. population for cancers of the brain and nervous system, thyroid, and female breast.

Table 6. Observed and expected cancer cases, Reserve Component aircrew compared to U.S. population, 1992-2017

Cancer site	Person-years	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	937,976	2,891	2,838	1.02	0.98	1.06	0.3239
Colon and rectum	957,309	189	276	0.68	0.59	0.79	<0.0001
Pancreas	958,421	46	63	0.73	0.53	0.97	0.0277
Melanoma	955,221	393	242	1.62	1.47	1.79	<0.0001
Prostate	894,841	785	670	1.17	1.09	1.26	<0.0001
Testis	899,298	78	101	0.77	0.61	0.97	0.0224
Urinary bladder	957,768	103	149	0.69	0.57	0.84	<0.0001
Kidney and renal pelvis	958,032	90	124	0.73	0.58	0.89	0.0017
Brain and nervous system	958,246	61	68	0.90	0.69	1.15	0.4416
Thyroid	957,792	89	76	1.16	0.93	1.43	0.1735
Non-Hodgkin lymphoma	957,509	138	169	0.82	0.69	0.97	0.0171
Female breast	57,703	53	52	1.03	0.77	1.34	0.8877
Lung and bronchus	958,236	113	305	0.37	0.31	0.45	<0.0001

Reserve Component ground crew members had statistically lower incidence of cancers of all sites (by 12 percent), colon and rectum (by 27 percent), pancreas (by 22 percent), testis (by 26 percent), urinary bladder (by 12 percent), brain and nervous system (by 16 percent), thyroid (by 13 percent), non-Hodgkin lymphoma (by 24 percent), female breast (by 12 percent), and lung and bronchus (by 35 percent), compared to individuals in the U.S. population (Table 7). There was no statistically significant difference for melanoma, prostate, and kidney and renal pelvis.

Table 7. Observed and expected cancer cases, Reserve Component ground crew compared to U.S. population, 1992-2017

Cancer site	Person-years	Observed cases	Expected cases	SIR	95% LL	95% UL	p-value
All sites	3,442,609	10,511	11,909	0.88	0.87	0.90	<0.0001
Colon and rectum	3,509,545	851	1,163	0.73	0.68	0.78	<0.0001
Pancreas	3,514,791	217	279	0.78	0.68	0.89	0.0001
Melanoma	3,508,506	791	845	0.94	0.87	1.00	0.064
Prostate	3,203,742	3,131	3,087	1.01	0.98	1.05	0.4381
Testis	3,224,915	241	325	0.74	0.65	0.84	<0.0001
Urinary bladder	3,511,351	565	639	0.88	0.81	0.96	0.0032
Kidney and renal pelvis	3,512,167	485	498	0.97	0.89	1.06	0.5642
Brain and nervous system	3,514,186	206	246	0.84	0.73	0.96	0.0106
Thyroid	3,513,029	238	274	0.87	0.76	0.99	0.0299
Non-Hodgkin lymphoma	3,511,602	500	655	0.76	0.70	0.83	<0.0001
Female breast	284,973	268	306	0.88	0.77	0.99	0.0287
Lung and bronchus	3,512,923	921	1,408	0.65	0.61	0.70	<0.0001

4 Discussion

4.1 Summary

This study found that compared to the U.S. population after adjusting for age, sex, and race, aircrew of all Components had a 75 percent higher rate of melanoma, 31 percent higher rate of thyroid cancer, and a 20 percent higher rate of prostate cancer. Ground crew members had a 12 percent higher incidence of kidney and renal pelvis cancer. This concludes the Phase 1 epidemiologic study required by section 750 of the NDAA for FY 2021 and initiates the Phase 2 study to identify risk factors for cancer diagnosis.

4.1.1 Cancer Incidence

The results of this Phase 1B study are generally similar to the results presented in Phase 1A, particularly for aircrew [1]. Both in Phase 1A, which looked at Active Component, and Phase 1B, which looked at all Components combined, there was a higher incidence of melanoma, prostate, and thyroid cancer in aircrew compared to the U.S. population. Among Reserve Component aircrew, melanoma, prostate, and thyroid cancer incidence was higher than the U.S. population, but thyroid cancer incidence was not statistically significant.

Ground crew members (all Components) had statistically higher incidence of kidney and renal pelvis cancer (by 12 percent), and Active Component ground crew had higher incidence of kidney and renal pelvis (by 21 percent) as well as thyroid (by 9 percent) cancer. However, Reserve Component ground crew had lower or similar rates of all cancers. In Phase 1A, Active Component ground crew had higher rates of cancer of the brain and nervous system (by 19 percent), thyroid (by 15 percent), melanoma (by 9 percent), and kidney and renal pelvis (by 9 percent). These differences in findings for Active Component ground crew may be due to differences in the study population (e.g., home of record exclusions and increased years of follow-up).

Although melanoma, thyroid, and prostate cancers were found to be elevated among aircrew, these cancers fortunately have some of the best survival rates [5]. It should be emphasized that in Phase 1A, aircrew and ground crew were found to have lower mortality rates for all cancers that were evaluated. One of the reasons why incidence of cancer diagnosis is higher among air crew and ground crew while mortality rates are lower could be due to differences in cancer screening rates. For example, current and former U.S. military service members have been found to have better screening rates for colorectal cancer, lung cancer, and prostate cancer [6-7]. Service members may have better screening rates since they receive free medical care while in active duty service and must adhere to strict physical fitness requirements.

This study did not collect data on cancer stage, which refers to how large the tumor is and how far it has spread. Patients diagnosed with late-stage cancer have shorter overall and cancer specific survival than early-stage disease. Information on cancer stage would help to understand the severity and life expectancy of the incident cancer cases identified. A recent study found that while active duty members had higher rates of prostate and breast cancers, analysis by tumor stage showed that this was primarily confined to localized stage, meaning that the cancer had not

spread to other regions of the body [8]. Additional studies would be required to determine the impact of differential cancer screening rates, as well as tumor stage, on the results of this analysis.

4.2 Study Strengths

As in Phase 1A, this was a large study including members who served in different military conflicts over time, and with a large enough population of women to evaluate female-specific cancers. An additional strength of the Phase 1B study is the inclusion of cancer registry data from the VACCR and VPR-CLS, which allowed better ascertainment of cases for Reserve and Guard members as well as veterans. The inclusion of DMSS data is a strength as it allowed cases to be included that may have been missing from the cancer registries. In particular, the DMSS case-finding algorithms have been found to work well for prostate, testis, and thyroid cancers, and for melanoma [9].

4.3 Study Limitations

4.3.1 Data Availability and Quality

Section 750 of the NDAA for FY 2021 defined the military study population as aviators or aviation support personnel who served in the Armed Forces on or after February 28, 1961, and receive benefits under 10 U.S.C., Chapter 55 (which includes Active and Reserve Component members). The task force was unable to identify an electronic data source containing information on military occupation and dates of service prior to 1990. The 2021 Air Force fighter aviator study included personnel with active duty service dating back to 1970, identified by the Air Force Personnel Center. However, not all of these Air Force members were included in the present study since standardized personnel data back to 1970 were not available for all Service branches.

Phase 1B was conducted to reduce known gaps in the military cancer case data; however, some gaps remain. Outpatient data were not available in DMSS until 1996. In addition, data in the DoD, VA, and State cancer registries became available at different times throughout the 1990s. Therefore, cancer data prior to 1997 should be considered incomplete. Exclusions to the study population were made based on home of record to reduce bias due to missing cancer registry data for some States. However, this likely did not completely remove this bias as it assumes that an individuals returned to their home State after separating from military service and continued to live there for the duration of the study period. Finally, it is estimated that two-thirds of cancer cases from Florida were missing from the analysis because of State-specific rules about the release of data that required individuals with certain information such as first and last name to be dropped if that information was missing.

As in Phase 1A, there were unavoidable differences in the ways that cancer incidence was calculated in the military cohort compared to how incidence was calculated in SEER. SEER uses mid-year population estimates as a proxy for the person-time at risk in the calendar year, and multiple tumors may be counted as cases. However, in the military cohort, rates are calculated by following individuals in the study population over time using person-years, and

only the first occurrence of each type of cancer is counted. The effect that this might have had on the final study results is unknown.

Although the AFHSD DMSS case-finding algorithms was found to perform well in a prior study for many of the cancers under investigation, administrative (i.e., claims-based) healthcare data such as those contained in DMSS are more susceptible to misclassification errors. Because of this, a sensitivity analysis was conducted in which the Phase 1B study was repeated with DMSS cancer data excluded. The sensitivity analysis found that after DMSS cases were excluded, there was no longer a significantly increased rate observed in any cancers among aircrew or ground crew compared to the U.S. population, with one exception. When DMSS cases were excluded, melanoma remained significantly elevated among aircrew (SIR=1.09, 95 percent CI=1.09, 1.17). Therefore, it should be noted that the findings of the Phase 1 study are dependent on the inclusion of these data. Had only cancer registry data been included, then there would not have been a significant increase reported in any of the cancers under study, except for melanoma among aircrew.

4.3.2 Exposure Misclassification

For both the Phase 1A and Phase 1B studies, DMOS codes were used to identify occupation groups, which has several limitations. Ideally, flight hours and the type of aircraft should be taken into consideration, but these data were not available. In addition, a person's occupation while in military service can change over time. Establishing a causal relationship between a person's military occupation and cancer would require that the exposure (i.e., occupation) or accumulation of exposure to a certain threshold (i.e., years spent in a certain occupation) occurs prior to first cancer diagnosis. The "usual occupation" approach does not take this temporality of exposure and cancer into consideration. Different cancers have different latency periods, which is the time that it takes for cancer to develop following the first exposure to a cancer-causing agent. These latency periods should be taken into consideration but were not for this study. However, the objective of this study was to compare cancer incidence rates in the military population to those in SEER, and latency periods are also not accounted for in the SEER rates.

Finally, DMOS codes are not standardized across service branches, which can lead to variability in the types of occupations selected into the aircrew and ground crew groups. The distinction between aircrew and ground crew was not clearly defined for some DMOS codes, and because data on flight hours were not available the determination was made by subject matter experts but may have resulted in some occupational misclassification.

4.3.3 Uncontrolled Confounding Factors

Due to the features of cancer registry and medical claims data, data are not available on family history of cancer, smoking, alcohol use, physical activity, overweight/obesity status, recreational environmental exposures, diet, and other lifestyle factors, which may confound the comparison of cancer incidence and mortality between the military study population and the U.S. population. The "healthy soldier" effect may also confound the results of this study. Since military members tend to be healthier than the general population by nature of being in military service, this may obscure any increased risk of cancer or cancer mortality due to occupational exposures.

4.4 Conclusions

The findings of this study suggest that aircrew and ground crew who served in the military have higher incidence of some cancers compared to individuals in the U.S. population. This finding cannot be generalized to members who served prior to 1990 because it does not include all members who served prior to this date. It also does not imply that military service in aircrew or ground crew occupations causes cancer, because there are multiple potential confounding factors that could not be controlled for in this analysis. The SIRs presented in this report should only be used to compare aircrew to the U.S. population and to compare ground crew to the U.S. population. They should not be used to compare cancer incidence rates between aircrew and ground crew since the methods used do not allow for this comparison. It is important to note that study results may have differed had additional older former Service members been included. Differences in screening rates in the military compared to the U.S. population could potentially explain the finding of increased rate of cancer diagnosis and lower mortality rates reported in Phase 1A; however, this requires further investigation.

4.5 Recommendations

Section 750 of the NDAA for FY 2021 states that Phase 2 shall be conducted if under Phase 1 there is determined to be an increased rate of cancers among military aircrew and ground crew. Given the findings of higher incidence for some cancers among aircrew and ground crew in the Phase 1A and Phase 1B studies, the Phase 2 study is required.

5 References

1. Department of Defense. Phase 1-a – Study on the Incidence of Cancer Diagnosis and Mortality among Military Aviators and Aviation Support Personnel. January 2023. Accessed February 7, 2024. Available at: https://www.health.mil/About-MHS/OASDHA/Defense-Health-Agency/Congressional-Relations/Reports-to-Congress/Signed-in-2023.
2. White MC, Babcock F, Hayes NS, et al. The history and use of cancer registry data by public health cancer control programs in the United States. Cancer. 2017;123 Suppl 24(Suppl 24):4969-4976. Doi:10.1002/cncr.30905
3. Robbins AS, Pathak SR, Webber BJ, Erich RA, Escobar JD, Simon AA, et al. (2020) Malignancy in U.S. Air Force fighter pilots and other officers, 1986–2017: A retrospective cohort study. PloS ONE 15(9): e0239437. https://doi.org/10.1371/journal.pone.0239437.
4. Armed Forces Health Surveillance Division. Surveillance Case Definitions. Available at: https://www.health.mil/Military-Health-Topics/Health-Readiness/AFHSD/Epidemiology-and-Analysis/Surveillance-Case-Definitions.
5. National Cancer Institute. Surveillance, Epidemiology, and End Results Program. Cancer Stat Facts: Common Cancer Sites. Accessed on March 13, 2024. Available at: https://seer.cancer.gov/statfacts/html/common.html.
6. Weygandt J, Robling K, Whitaker LA, McPherson K, Hartwell M, Greiner B. Cancer Screening Among Current and Former U.S. Military Personnel Compared to Civilians: A Cross-Sectional Analysis of the Behavioral Risk Factor Surveillance System. Mil Med. Published online December 4, 2021. Doi:10.1093/milmed/usab439
7. Hoffman SS, Smith AW, Kent EE, Doria-Rose VP, Kobrin SC, Mollica MA. Examination of prostate-specific antigen (PSA) screening in military and civilian men: analysis of the 2018 behavioral risk factor surveillance system. Cancer Causes Control. 2022;33(3):393-402. Doi:10.1007/s10552-021-01533-y
8. Bytnar JA, McGlynn KA, Nealeigh MD, Shriver CD, Zhu K. Cancer incidence in the US military: An updated analysis. Cancer. 2024;130(1):96-106. Doi:10.1002/cncr.34978
9. Webber BJ, Rogers AE, Pathak SR, Robbins AS. Positive predictive value of an algorithm used for cancer surveillance in the U.S. Armed Forces. MSMR. 2019 Dec;26(12):18-22. PMID: 31860325.

6 Acknowledgements and Disclaimers

The authors would like to acknowledge the contribution to this study from central cancer registries supported through the Centers for Disease Control and Prevention's (CDC) National Program of Cancer Registries (NPCR) and/or the NCI's SEER Program. Central registries may also be supported by State agencies, universities, and cancer centers. Participating central cancer registries include the following: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Puerto Rico, Rhode Island, Seattle-Puget Sound (Washington), South Carolina, Tennessee, Utah, Virginia, West Virginia, Wisconsin, and Wyoming.

Additional State-specific acknowledgments and disclaimers are provided below.

Data for Alabama were provided by the Alabama Statewide Cancer Registry.

The collection of cancer incidence data used in this study was supported by the California Department of Public Health pursuant to California Health and Safety Code Section 103885; CDC National Program of Cancer Registries, under cooperative agreement 1NU58DP007156; the NCI's Surveillance, Epidemiology and End Results Program under contract HHSN261201800032I awarded to the University of California, San Francisco, contract HHSN261201800015I awarded to the University of Southern California, and contract HHSN261201800009I awarded to the Public Health Institute. The ideas and opinions expressed herein are those of the author(s) and do not necessarily reflect the opinions of the State of California, Department of Public Health, the NCI, and the CDC or their Contractors and Subcontractors.

Data was collected and provided, in part, by the Colorado Central Cancer Registry (CCCR). The CCCR and the Colorado Department of Public Health and Environment specifically disclaim responsibility for any analyses, interpretations, or conclusions they have not provided.

The Florida cancer incidence data used in this report were collected by the Florida Cancer Data System, the Statewide cancer registry funded by the Florida Department of Health (DOH) and the Centers for Disease Control and Preventions National Program of Cancer Registries (CDC-NPCR). The views expressed herein are solely those of the author(s) and not necessarily reflect those of the DOH or CDC-NPCR.

The authors acknowledge the Illinois Department of Public Health, Illinois State Cancer Registry as a source of data for this study. The conclusions, opinions, or recommendations in this study are not necessarily the conclusions, opinions, or recommendations of the Department.

Cancer data was provided by the Maryland Cancer Registry, Center for Cancer Prevention and Control, Maryland Department of Health, with funding from the State of Maryland and the Maryland Cigarette Restitution Fund. The collection and availability of cancer registry data is also supported by the Cooperative Agreement NU58DP007114, funded by the CDC. Its contents

are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or the Department of Health and Human Services.

The authors acknowledge the New Hampshire Department of Health and Human Services as a source of the data in this study. The analyses, conclusions, interpretations, and recommendations drawn from these data are solely those of the authors and not necessarily those of the New Hampshire Department of Health and Human Services.

This study was supported by Rutgers, The State University of New Jersey, on behalf of its RBHS-Cancer Institute of New Jersey, New Jersey State Cancer Registry and Cancer Surveillance Research Program.

Data for North Carolina were provided by North Carolina Department of Health and Human Services, Division of Public Health. The findings and conclusions in this publication are those of the authors and do not necessarily represent the views of the North Carolina Department of Health and Human Services, Division of Public Health.

Data used in this publication were provided by the North Dakota Statewide Cancer Registry, Grand Forks, ND.

Cancer incidence data used in these analyses were obtained from the Ohio Cancer Incidence Surveillance System, Ohio Department of Health (ODH), a cancer registry partially supported by the National Program of Cancer Registries at the CDC through Cooperative Agreement Number NU58DP007097. Use of these data does not imply that ODH or CDC agrees or disagrees with the analyses, interpretations, or conclusions in this report.

Data were supplied by the Bureau of Health Statistics & Registries, Pennsylvania Department of Health, Harrisburg, Pennsylvania. The Pennsylvania Department of Health specifically disclaims responsibility for any analyses, interpretations, or conclusions.

Data for South Carolina were provided by the South Carolina Central Cancer Registry, Bureau of Population Health Data Analytics & Informatics, South Carolina Department of Health and Environmental Control.

Tennessee Department of Health Data used were obtained from Tennessee Cancer Registry, Tennessee Department of Health (TDH). Use of these data does not imply TDH agrees or disagrees with any presentations, analysis, interpretations, or conclusions herein.

The views expressed in this report are those of the authors and do not necessarily reflect the position of the Virginia Cancer Registry under the Virginia Department of Health.

Appendix A

Acronyms

AFHSD	Armed Forces Health Surveillance Division
CCCR	Colorado Central Cancer Registry
CDC	Centers for Disease Control and Prevention
DHA	Defense Health Agency
DMOS	Duty Military Occupational Specialty
DMSS	Defense Medical Surveillance System
DoD	Department of Defense
DOH	Florida Department of Health
FY	Fiscal Year
ICD	International Classification of Diseases
NAACCR	North American Association of Central Cancer Registries
NCI	National Cancer Institute
NDAA	National Defense Authorization Act
NPCR	National Program of Cancer Registries
ODH	Ohio Department of Health
SEER	Surveillance, Epidemiology, and End Results
SIR	standardized incidence ratio
TDH	Tennessee Department of Health
VA	Department of Veterans Affairs
VACCR	Veterans Affairs Central Cancer Registry
VPR-CLS	Virtual Pooled Registry Cancer Linkage System

Appendix B

Standardized Incidence Ratio (SIR)

The SIR is a ratio of the number of observed cancer cases in the military aircrew and ground crew compared to the number that would be expected to occur in the aircrew and ground crew if they experienced the same cancer rates at the U.S. population. The SIR adjusts for differences in age, sex, and race/ethnicity.

$$SIR = \frac{Observed\ Cancer\ Cases\ (O)}{Expected\ Cancer\ Cases\ (E)}$$