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ORIGINAL ARTICLE

Cancer incidence in the US military: An updated analysis

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Abstract

Background: Military and general populations differ in factors related to cancer occurrence and diagnosis. This study compared incidence of colorectal, lung, prostate, testicular, breast, and cervical cancers between the US military and general US populations.

Methods: Data from the US Department of Defense's Automated Central Tumor Registry (ACTUR) and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program were analyzed. Persons in ACTUR were active-duty members 20–59 years old during 1990–013. The same criteria applied to persons in SEER. Age-adjusted incidence rates, incidence rate ratios, and 95% confidence intervals were calculated by sex, race, age, and cancer stage. Temporal trends were analyzed.

Results: ACTUR had higher rates of prostate and breast cancers, particularly in 40- to 59-year-olds. Further analyses by tumor stage showed this was primarily confined to localized stage. Incidence rates of colorectal, lung, testicular, and cervical cancers were significantly lower in ACTUR than in SEER, primarily for regional and distant tumors in men. Temporal incidence trends were generally similar overall and by stage between the populations, although distant colorectal cancer incidence tended to decrease starting in 2006 in ACTUR whereas it increased during the same period in SEER.

Conclusion: Higher rates of breast and prostate cancers in servicemembers 40–59 years of age than in the general population may result from greater cancer screening utilization or cumulative military exposures. Lower incidence of other cancers in servicemembers may be associated with better health status.

KEYWORDS
cancer, cancer registry, epidemiology, incidence, military, SEER

INTRODUCTION

Active-duty military servicemembers differ from the general US population in factors that may be related to cancer incidence. The military has a younger age structure, is predominantly male, and is generally healthier than the general US population.[1,2] Servicemembers experience unique occupational environments, possibly varying from the general population in factors such as occupational chemical exposures,[3,4] unhealthy dietary intake, tobacco and alcohol consumption,[5,6] and protective factors such as physical activity and healthy body weight.[5,6] Servicemembers have no-cost universal health care and may be more likely to receive cancer screening[7–10] and timely care. As a result, cancer incidence may vary between the military and general populations.

We previously compared the US active-duty to the general population in the incidence rates of lung, colorectal, testicular, prostate, cervical, and breast cancers.[11] Servicemembers had lower rates of colorectal, lung, and cervical cancers but higher rates of breast and prostate cancers than the general US population.[11] Since that original study, there were several studies of specific cancers comparing the two populations. One study found the incidence rate of non-seminoma testicular cancer was lower in the military than the general population but both had similar temporal trends.[12] Another study found that whereas younger servicemen had lower incidence of colorectal cancer, the differences disappeared between the military and general population among individuals 40 years and older.[13]

Our prior study[11] was limited by relatively small case numbers among servicemembers, thus, analyses stratified by age and tumor stage could not be conducted. Examination by age and tumor stage, in addition to sex and race, could provide clues as to the differences between the populations. This study aimed to expand our original analyses using updated data with a larger number of cancer cases over a longer period. Specifically, we compared incidence rates of lung, colorectal, testicular, prostate, cervical, and breast cancers between the US military and general populations stratified by race, sex, age, and tumor stage. We also examined temporal trends in incidence by sex, age, race, and tumor stage for selected cancers.

MATERIALS AND METHODS

Data sources and study populations

Data for the military were obtained from the Department of Defense's (DoD) Automated Central Tumor Registry (ACTUR). ACTUR was begun in 1986 to record cancers among DoD beneficiaries diagnosed or treated within the Military Health System. Those eligible for inclusion to the current analysis were Black and White active-duty servicemembers 20–59 years old diagnosed with invasive colorectal, lung, testicular, prostate, ovarian, or breast cancer during the years 1990–2013. Adults 60 years and older were not included because the number of persons within these age groups is not large in the military. Multiple cancer records were consolidated forming one record for each primary cancer using national and state registry guidelines that are described elsewhere.[11] The Defense Manpower Data Center supplied active-duty annual population counts.

Data for the general population were obtained from the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) database. The same criteria as those for ACTUR were applied. Data from the SEER-9 registries that represent approximately 10% of the U.S. population were used.[14] The annual population size for the SEER-9 areas was also obtained through SEER.

Study variables

Cancers were defined based on ICD-O-3 topographic codes: colorectal (C180, C182-189, C199, and C209), lung (C340–C349), testicular (C620–C629), prostate (C619), cervical (C530–C539), and breast cancers (C500–C509). SEER summary stage was used to define tumor stages (local, regional, and distant). Local and regional prostate cancer stages were combined based on SEER staging procedures.[15] Additional demographic variables used in the analysis included sex (male, female), race (White, Black), and age group (20–39 and 40–59 years). Other racial groups were not included due to limited numbers.

Statistical analysis

Age-adjusted incidence rates (per 100,000 person-years) and 95% confidence intervals (CIs) were calculated. The active-duty population from the whole period (1990–2013) was used as the standard population to give more weight to the younger age groups overrepresented in the military. Age in years was used in age adjustment. Incidence rate ratios (IRR) and 95% CIs were calculated to compare incidence rates in the active-duty population to those in SEER. The 95% CIs for all rates were calculated using the Tiwari method.[16] Analyses were performed overall and by race, sex, and age category for each cancer site. The analyses were further stratified by tumor stage. To further assess the possible role of cancer screening and additional age-related factors, we subdivided those 40–59 years old into 40–49 and 50–59 years because the latter were generally more likely to undergo cancer screening based on many national recommendations. Some statistical analyses among women and Black servicemembers were not able to be conducted due to small numbers of individuals. Analyses by age, race, and stage were performed for selected cancers that had more than 10 cases after stratification.

To analyze temporal trends, we calculated the average annual percentage change (APC) in incidence within each population and compared different time periods using log-linear Joinpoint Regression. Data for all cancer types except prostate cancer were modeled under the assumption of constant variance. Data for prostate cancer exhibited heteroscedasticity and were modeled using standard errors and a weighted Bayesian information criterion. Trend analyses were further examined by demographic and tumor variables for selected cancers with more than 10 annual cases per time point after stratification. Prostate cancer trends by stage were modeled for the period 1995–2013 because there was a lack of summary staging in SEER before 1995. Analyses were conducted with a significance level set at $p < .05$ using SAS version 9.4 (SAS Institute, Cary, North Carolina) and Joinpoint Regression (version 4.9.0.0, NCI).

RESULTS

Table 1 shows sex-specific incidence rates and rate ratios for colorectal, lung, prostate, testicular, breast, and cervical cancer by race in ACTUR and SEER. Colorectal cancer incidence was significantly lower in ACTUR among men (White: IRR, 0.79, 95% CI, 0.73–0.85; Black: IRR, 0.83, 95% CI, 0.72–0.96), but not among women. Lung cancer incidence was significantly lower in ACTUR among both men

TABLE 1 Sex-specific incidence rates and rate ratios of colorectal, lung, prostate, testicular, breast, and cervical cancers by race among those 20–59 years old in the US active-duty military (ACTUR) and the general US (SEER) populations, 1990–2013.

	ACTUR						SEER						ACTUR:SEER			
	White			Black			White			Black			White		Black	
Cancer site	Count	Rate[a]	95% CI	Count	Rate[a]	95% CI	Count	Rate[a]	95% CI	Count	Rate[a]	95% CI	IRR[b]	95% CI	IRR[b]	95% CI
Men																
Colorectal	756	3.65	3.39–3.92	231	4.61	4.03–5.24	30,933	4.64	4.53–4.74	5,305	5.55	5.25–5.86	0.79	0.73–0.85	0.83	0.72–0.96
Lung	340	1.64	1.47–1.82	85	1.70	1.35–2.10	32,012	2.95	2.87–3.02	7,716	5.33	5.06–5.62	0.56	0.50–0.62	0.32	0.25–0.40
Prostate	1,250	6.03	5.70–6.38	542	10.81	9.92–11.76	68,336	2.60	2.56–2.64	16,550	4.72	4.55–4.89	2.32	2.19–2.46	2.29	2.08–2.51
Testis	2,640	12.74	12.26–13.23	105	2.09	1.71–2.54	15,615	13.82	13.56–14.08	454	2.35	2.11–2.62	0.92	0.88–0.96	0.89	0.70–1.11
Women																
Colorectal	85	3.32	2.65–4.10	52	3.81	2.85–5.00	23,166	3.51	3.41–3.61	5,174	4.51	4.26–4.77	0.95	0.75–1.17	0.85	0.62–1.12
Lung	46	1.79	1.31–2.39	27	1.98	1.30–2.88	27,899	2.48	2.41–2.55	5,371	3.19	3.01–3.38	0.72	0.52–0.97	0.62	0.40–0.91
Breast	736	28.71	26.67–30.86	449	32.93	29.95–36.12	159,572	27.21	26.98–27.45	23,470	31.09	30.42–31.76	1.06	0.98–1.13	1.06	0.96–1.16
Cervix	143	5.58	4.70–6.57	37	2.71	1.91–3.74	14,175	6.80	6.64–6.96	2,686	6.82	6.46–7.20	0.82	0.69–0.97	0.40	0.28–0.55

Abbreviations: ACTUR, Automated Central Tumor Registry; CI, confidence interval; IRR, incidence rate ratios; SEER, Surveillance, Epidemiology, and End Results.

[a]Age-adjusted incidence rate and 95% CIs. All incidence rates were adjusted to the active-duty military population.

[b]IRR and 95% CIs.

and women (White men: IRR, 0.56, 95% CI, 0.50–0.62; Black men: IRR, 0.32, 95% CI, 0.25–0.40; White women: IRR, 0.72, 95% CI, 0.52–0.97; Black women: IRR, 0.62, 95% CI, 0.40–0.91).

The comparison of sex-specific cancers among men found that prostate cancer incidence was significantly higher in ACTUR among both White and Black men (White: IRR, 2.32, 95% CI, 2.19–2.46; Black: IRR, 2.29, 95% CI, 2.08–2.51). In contrast, testicular cancer incidence in ACTUR was significantly lower among White men but not among Black men (IRR, 0.92, 95% CI, 0.88–0.96). Among women, there were no differences in breast cancer incidence, but there were in cervical cancer incidence. Both White (IRR, 0.82, 95% CI, 0.69–0.97) and Black women (IRR, 0.40, 95% CI, 0.28–0.55) in ACTUR had significantly lower rates of cervical cancer than did women in SEER.

Table 2 shows cancer incidence rates by race and age. Rates of colorectal and lung cancers were generally lower in ACTUR than SEER among men in both age groups. Among women, the rate of colorectal cancer was lower in ACTUR than SEER in the younger group but not in the older group, whereas the rates of lung cancer tended to be lower in both age groups. Significantly higher incidence rates of prostate and breast cancers in ACTUR were only observed among 40- to 59-year-olds (White: IRR, 2.37, 95% CI, 2.23–2.51; Black: IRR, 2.39, 95% CI, 2.16–2.62 for prostate cancer; White: IRR, 1.15, 95% CI, 1.04–1.26; Black: IRR, 1.17, 95% CI, 1.01–1.34 for breast cancer).

Table 3 shows cancer incidence rates by race, age, and tumor stage. Lower rates of colorectal and lung cancers in ACTUR than SEER among White and Black men 40–59 years old tended to be more pronounced for distant stage tumors. For example, among White men with distant staged lung cancer, the IRR was 0.40 and its 95% CI was 0.32–0.49 compared to the corresponding numbers of 0.77 and 0.59–0.97 for regionally stage lung cancer. Analysis further dividing the 40- to 59-year-olds age group into 40–49 and 50–59 revealed similar patterns to those observed in the overall 40- to 59-year olds age group for localized colorectal and lung cancers (data not shown). For colorectal cancer, the rates of localized cancer were insignificantly higher in ACTUR than SEER (White: IRR, 1.08, 95% CI, 0.92–1.25; Black: IRR, 1.25, 95% CI, 0.88–1.70). Further dividing the 40- to 59-year olds group into 40–49 and 50–59 shows a significantly higher rate in ACTUR than SEER (IRR, 1.44, 95% CI, 1.08–1.83) among White men 50–59 years old (data not shown). The IRR for prostate tumors among 40- to 59-year-olds was significantly higher for local/regional stage tumors (the number was too small for analysis for distant stage tumors). Rates were similarly higher in ACTUR when the ages were stratified into 40–49 and 50–59 years (data not shown).

Among women, higher rates of breast cancer in ACTUR among 40–59-year-olds were confined to localized stage tumors (White IRR, 1.18, 95% CI, 1.03-1.33; Black IRR, 1.23, 95% CI, 1.00-1.49) (Table 3). Further analysis dividing ages 40–59 years into 40–49 and 50–59 years found that the differences were more evident for the older group for local stage tumors among White women (IRR, 1.42, 95% CI, 1.01–1.87) and regional stage tumors among Black women (IRR, 2.68, 95% CI, 1.24–4.36) (data not shown).

Figure 1 shows temporal trends in the incidence of colorectal, prostate, and breast cancers among individuals 20- to 59-years-old. Colorectal cancer rates increased among White men from 1990 to 2008 in ACTUR (APC = 2.56, $p = .013$) and from 1990 to 2013 in SEER (APC = 1.76, $p < .0001$). The rates among Black men were not calculated due to small numbers. Prostate cancer rates among White men increased in ACTUR until 2004 (APC = 11.21, $p < .001$) then significantly declined (APC = −9.45, $p < .001$) whereas in SEER rates increased until 1999 (APC = 10.31, $p < .001$), plateaued until 2009 (APC = 2.23, $p < .01$), then declined (APC = −10.17, $p = .001$). Prostate cancer rates among Black men were statistically parallel between ACTUR and SEER, whereas the rates were higher in ACTUR than SEER throughout the study period. Incidence increased through 2000 (combined APC = 17.52, $p = .006$) then plateaued. Breast cancer incidence rates were relatively stable among both Black and White women although rates tended to be higher in ACTUR than SEER.

Figure 2 shows temporal trends in localized colorectal, prostate, and breast cancer rates among individuals 40–59 years old. Colorectal cancer rates increased among White men in both ACTUR and SEER but the APC was significant only in SEER (APC = 1.24, $p < .0001$). Prostate cancer trends were similar to those for all men with higher rates in ACTUR over time. Prostate cancer rates in ACTUR increased significantly until 2005 for White men and until 2001 for Black men, then decreased. In SEER, prostate cancer rates increased until 2009 for White men and until 2001 for Black men, then declined. Among White men, further examination of trends for those 40-49 years old and 50–59 years old separately showed similar patterns to the overall trends (data not shown). For breast cancer, there were no significant differences in trends, although rates tended to be higher for ACTUR in most time periods. This same pattern was seen when the rates were stratified into those among 40- to 49-year-olds and 50- to 59-year-olds.

Temporal trends of lung and testicular cancers among White men and cervical cancer among White women were also examined (data not shown). Rates of lung and cervical cancers were lower for ACTUR than SEER in all time periods. Trends were similar between the populations with declining rates for lung and cervical cancers and increasing rates for testicular cancer (data not shown). For lung and testicular cancers, trends were similar in populations for all tumor stages.

DISCUSSION

This study generated several new findings. First, incidence rates of colorectal, lung, and testicular cancers were lower in the military than the general population in men, and the differences tended to be smaller among 40- to 59-year-olds than 20- to 39-year-olds and larger for regional and/or distant tumors. Second, higher rates of prostate and breast cancers in the military occurred in 40- to 59-year-olds. These differences were particularly observed for localized tumors.

TABLE 2 Sex-specific incidence rates and rate ratios of colorectal, lung, prostate, testicular, breast, and cervical cancers by race and age among those 20–59 years old in the US active-duty military (ACTUR) and the general US (SEER) populations, 1990–2013.[a]

		ACTUR						SEER						ACTUR:SEER			
		White			Black			White			Black			White		Black	
Cancer site	Age, years	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	IRR[c]	95% CI	IRR[c]	95% CI
Men																	
Colorectal	20–39	349	1.89	1.70–2.10	110	2.44	2.01–2.94	2701	2.69	2.58–2.80	483	3.31	3.02–3.63	0.70	0.63–0.79	0.74	0.59–0.91
	40–59	407	18.00	16.30–19.84	121	23.71	19.68–28.33	28,232	20.57	20.16–20.98	4822	25.26	23.93–26.64	0.88	0.79–0.97	0.94	0.77–1.13
Lung	20–39	109	0.59	0.48–0.71	28	0.62	0.41–0.90	1234	1.18	1.12–1.26	368	2.50	2.25–2.78	0.50	0.40–0.61	0.25	0.16–0.37
	40–59	231	10.22	8.94–11.62	57	11.17	8.46–14.47	30,778	17.33	16.98–17.69	7348	30.32	28.93–31.75	0.59	0.51–0.67	0.37	0.28–0.48
Prostate	20–39	35	0.19	0.13–0.26	22	0.49	0.31–0.74	157	0.14	0.11–0.16	69	0.42	0.32–0.53	1.38	0.89–2.02	1.18	0.66–1.93
	40–59	1215	53.74	50.76–56.85	520	101.91	93.33–111.05	68,179	22.68	22.36–23.00	16,481	42.67	41.25–44.12	2.37	2.23–2.51	2.39	2.16–2.62
Testis	20–39	2402	13.01	12.49–13.54	99	2.20	1.79–2.68	10,917	14.29	14.00–14.58	297	2.38	2.11–2.67	0.91	0.87–0.95	0.93	0.72–1.17
	40–59	238	10.53	9.23–11.95	—	—	—	4698	9.98	9.63–10.34	157	2.14	1.71–2.63	1.05	0.92–1.20	—	—
Women																	
Colorectal	20–39	42	1.81	1.30–2.44	20	1.61	0.98–2.49	2160	2.09	1.99–2.20	209	2.78	2.53–3.04	0.86	0.61–1.17	0.58	0.34–0.91
	40–59	43	18.15	13.13–24.44	32	26.44	18.08–37.32	21,006	17.39	17.00–17.77	4665	22.26	21.15–23.41	1.04	0.73–1.41	1.18	0.78–1.68
Lung	20–39	17	0.73	0.43–1.17	—	—	—	1124	1.02	0.95–1.09	276	1.41	1.24–1.60	0.72	0.40–1.15	—	—
	40–59	29	12.24	8.20–17.58	17	14.04	8.18–22.49	26,775	16.76	16.41–17.11	5095	21.48	20.43–22.58	0.73	0.48–1.05	0.65	0.36–1.05
Breast	20–39	322	13.84	12.37–15.44	247	19.88	17.48–22.52	17,810	14.47	14.25–14.70	3845	20.21	19.55–20.89	0.96	0.85–1.07	0.98	0.86–1.12
	40–59	414	174.73	158.30–192.39	202	166.88	144.66–191.55	141,762	152.27	151.08–153.47	19,625	142.76	139.66–145.89	1.15	1.04–1.26	1.17	1.01–1.34
Cervix	20–39	119	5.11	4.24–6.12	33	2.66	1.83–3.73	5988	6.14	5.96–6.31	987	5.87	5.49–6.27	0.83	0.68–1.00	0.45	0.31–0.64
	40–59	24	10.13	6.49–15.07	—	—	—	8187	13.29	12.90–13.68	1699	16.56	15.46–17.70	0.76	0.47–1.14	—	—

Abbreviations: ACTUR, Automated Central Tumor Registry; CI, confidence interval; IRR, incidence rate ratios; SEER, Surveillance, Epidemiology, and End Results.

[a]Empty cells were not calculated due to small sample sizes.

[b]Age-adjusted incidence rate and 95% CIs. All incidence rates were adjusted to the active-duty military population.

[c]Incidence rate ratio and 95% confidence intervals.

TABLE 3 Incidence rates and rate ratios of colorectal, lung, prostate, and testicular cancers among men and breast and cervical cancers by age, race, and tumor stage among individuals 20–59 years old in the US active-duty (ACTUR) and the general US (SEER) populations, 1990–2013.[a]

			ACTUR						SEER						ACTUR:SEER			
			White			Black			White			Black			White		Black	
Cancer site	Age, years	Stage	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	IRR[c]	95% CI	IRR[c]	95% CI
Men																		
Colorectal	20–39	Local	111	0.60	0.49–0.72	40	0.89	0.63–1.21	821	0.82	0.76–0.88	161	1.10	0.94–1.29	0.74	0.59–0.90	0.81	0.55–1.15
		Regional	138	0.75	0.63–0.88	34	0.76	0.52–1.06	1066	1.06	0.99–1.13	161	1.11	0.94–1.30	0.71	0.58–0.85	0.68	0.45–0.99
		Distant	83	0.45	0.36–0.56	29	0.64	0.43–0.93	631	0.62	0.57–0.68	119	0.81	0.67–0.97	0.72	0.56–0.91	0.80	0.50–1.20
	40–59																	
		Local	180	7.96	6.84–9.21	47	9.21	6.77–12.25	11,064	7.38	7.14–7.63	11,064	7.35	6.68–8.07	1.08	0.92–1.25	1.25	0.88–1.70
		Regional	152	6.72	5.70–7.88	45	8.82	6.43–11.80	10,374	7.94	7.68–8.21	10,374	9.49	8.67–10.35	0.85	0.71–1.00	0.93	0.66–1.26
		Distant	67	2.96	2.30–3.76	24	4.70	3.01–7.00	5853	4.46	4.27–4.65	5853	7.20	6.48–7.96	0.66	0.51–0.85	0.65	0.40–0.99
Lung	20–39																	
		Local	34	0.18	0.13–0.26	—	—	—	200	0.22	0.19–0.25	—	—	—	0.84	0.55–1.22	—	—
		Regional	35	0.19	0.13–0.26	—	—	—	235	0.22	0.19–0.26	—	—	—	0.85	0.57–1.23	—	—
		Distant	32	0.17	0.12–0.24	—	—	—	610	0.56	0.51–0.61	—	—	—	0.31	0.21–0.44	—	—
	40–59																	
		Local	58	2.57	1.95–3.32	19	3.72	2.24–5.81	3781	1.95	1.83–2.07	780	2.53	2.17–2.94	1.32	0.97–1.72	1.47	0.80–2.37
		Regional	72	3.18	2.49–4.01	15	2.94	1.65–4.85	7592	4.15	3.98–4.32	1718	6.72	6.07–7.42	0.77	0.59–0.97	0.44	0.24–0.73
		Distant	92	4.07	3.28–4.99	18	3.53	2.09–5.57	17,842	10.22	9.95–10.50	4649	19.01	17.91–20.14	0.40	0.32–0.49	0.19	0.11–0.29
Prostate	40–59																	
		Local/ regional	1078	62.88	59.18–66.75	504	121.91	111.50–113.03	58,949	24.85	24.48–25.22	14,342	46.59	44.98–48.24	2.53	2.37–2.69	2.62	2.36–2.88
		Distant	11	0.64	0.32–1.15	—	—	—	1587	0.79	0.72–0.87	—	—	—	0.81	0.37–1.46	—	—
Testis	20–39																	
		Local	1872	9.13	8.70–9.57	—	—	—	7780	9.95	9.71–10.19	—	—	—	0.92	0.87–0.97	—	—
		Regional	485	2.42	2.20–2.65	—	—	—	1923	2.62	2.49–2.75	—	—	—	0.92	0.83–1.02	—	—
		Distant	231	1.21	1.05–1.38	—	—	—	1081	1.54	1.45–1.65	—	—	—	0.78	0.67–0.91	—	—

TABLE 3 (Continued)

Cancer site	Age, years	Stage	ACTUR						SEER						ACTUR:SEER			
			White			Black			White			Black			White		Black	
			Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	Count	Rate[b]	95% CI	IRR[c]	95% CI	IRR[c]	95% CI
	40–59																	
		Local	187	8.27	7.13–9.55	—	—	—	3343	7.19	6.89–7.49	—	—	—	1.15	0.98–1.34	—	—
		Regional	39	1.73	1.23–2.36	—	—	—	822	1.73	1.58–1.88	—	—	—	1.00	0.68–1.38	—	—
Women																		
Breast	20–39																	
		Local	153	6.58	5.58–7.70	118	9.50	7.86–11.37	8873	7.17	7.01–7.33	1619	8.42	8.00–8.86	0.92	0.77–1.08	1.13	0.92–1.36
		Regional	144	6.19	5.22–7.29	103	8.29	6.77–10.05	7664	6.24	6.10–6.40	1765	9.23	8.78–9.69	0.99	0.83–1.17	0.90	0.72–1.10
		Distant	14	0.60	0.33–1.01	16	1.29	0.74–2.09	868	0.71	0.66–0.76	344	1.90	1.69–2.13	0.85	0.43–1.44	0.68	0.37–1.12
	40–59																	
		Local	250	105.51	92.84–119.43	107	88.40	72.44–106.82	86,867	89.52	88.61–90.43	10,170	71.66	69.49–73.88	1.18	1.03–1.33	1.23	1.00–1.49
		Regional	141	59.51	50.09–70.18	84	69.40	55.35–85.92	46,811	54.44	53.72–55.17	7486	57.37	55.41–59.38	1.09	0.91–1.29	1.21	0.95–1.50
		Distant	14	5.91	3.23–9.91				6053	6.05	5.81–6.29				0.98	0.49–1.64		
Cervical	20–39																	
		Local	100	4.30	3.50–5.23	—	—	—	4283	4.46	4.31–4.61	—	—	—	0.96	0.77–1.18	—	—
		Regional	16	0.69	0.39–1.12	—	—	—	1134	1.05	0.99–1.12	—	—	—	0.65	0.36–1.07	—	—

Abbreviations: ACTUR, Automated Central Tumor Registry; CI, confidence interval; IRR, incidence rate ratios; SEER, Surveillance, Epidemiology, and End Results.

[a]Empty cells were not calculated due to small sample sizes.

[b]Age-adjusted incidence rate and 95% confidence intervals. All incidence rates were adjusted to the active-duty military population.

[c]Incidence rate ratio and 95% confidence intervals.

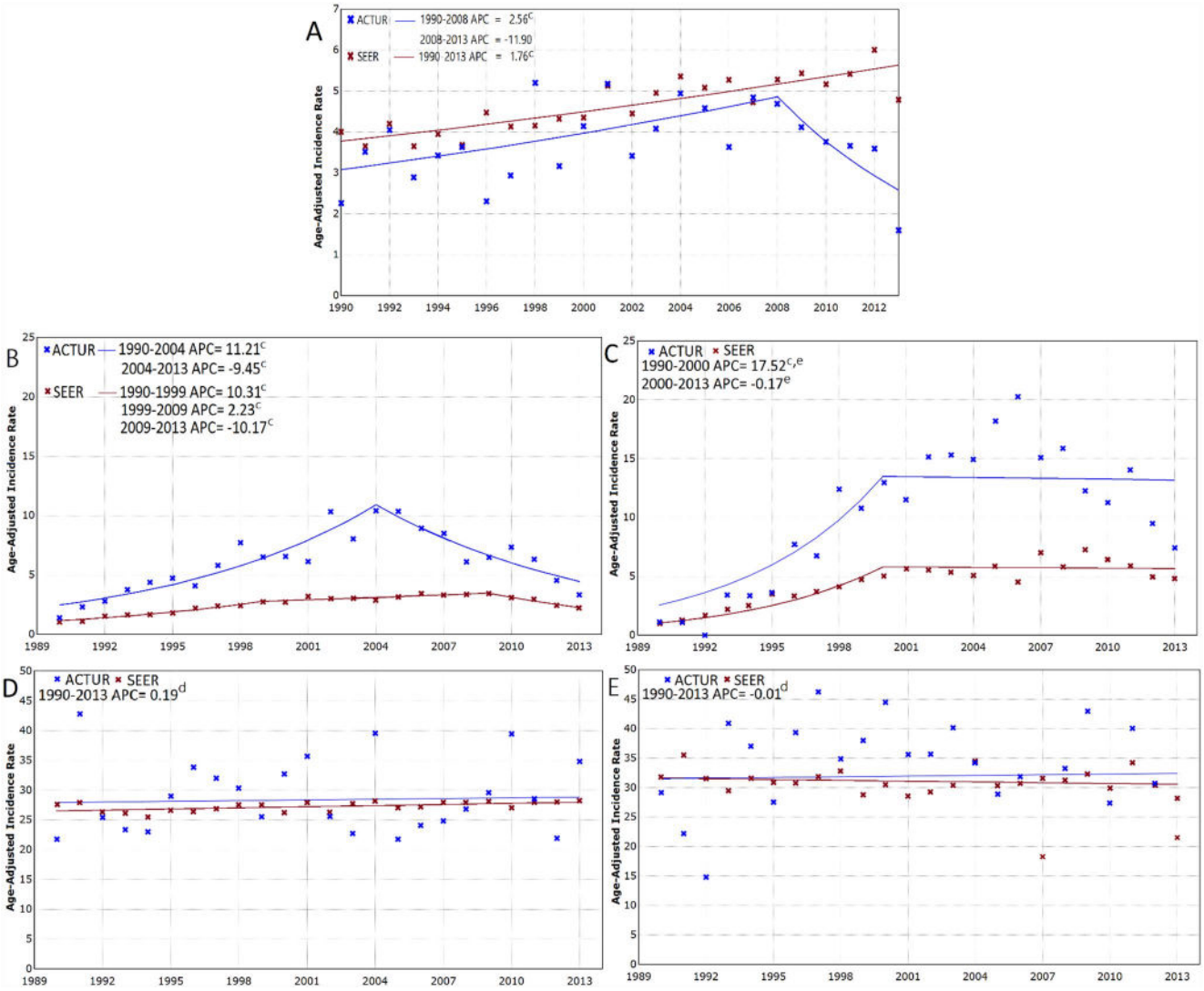

FIGURE 1 Trends in age-adjusted incidence rates[a] of colorectal,[b] prostate, and breast cancer among individuals 20- to 59-year-olds in the US active-duty (ACTUR) and the general US (SEER) populations, 1990–2013. (A) Colorectal cancer incidence trends among White men. (B) Prostate cancer incidence trends among White men. (C) Prostate cancer incidence trends among Black men. (D) Breast cancer incidence trends among White women. (E) Breast cancer incidence trends among Black women. [a]All incidence rates were adjusted to the active-duty military population. [b]Trends for colorectal cancer in Black men were not calculated due to small annual sample sizes. [c]Indicates the annual percentage change is significantly different than zero. [d]The two trends are statistically equivalent. [e]The two trends are statistically parallel.

Lower rates of colorectal, lung, cervical cancers, and other malignancies in US servicemembers have been previously reported.[11–13,17–19] These lower rates may result from the healthier status of military personnel. Individuals not meeting specific strict medical standards are not eligible to join the military, and servicemembers must maintain weight and physical fitness standards throughout their service with annual medical assessments. Free, universal health care access may make it more likely for servicemembers to have cancer precursors detected and treated. Lower lung and cervical cancer rates in servicemembers (that were more prominent among Black than White persons) may also be related to the presence of free medical care, differentially reducing barriers to care more for Black than White persons. However, we found differences between the populations tended to be smaller or not present among 40- to 59-year-olds, which might result from cumulative military exposures to risk factors such as ionizing radiation, polychlorinated biphenyls, burn pits, dust storms, metals, other chemicals,[3,4,20–25] as well as alcohol and tobacco use.[5,6] Effects of these cumulative exposures might be somewhat offset by healthier status in adulthood and protective factors associated with military service.

Higher rates of prostate and breast cancers in the military among 40- to 59-year-olds occurred particularly for localized tumors; the differences tended to be larger for breast cancer when further confining the analysis to 50- to 59-year-olds. These findings might result from greater utilization of cancer screening and high accessibility to care in the military. Although no joint screening guidelines exist between military branches, most recommend screening for breast and prostate cancers beginning at age 40 for average-risk

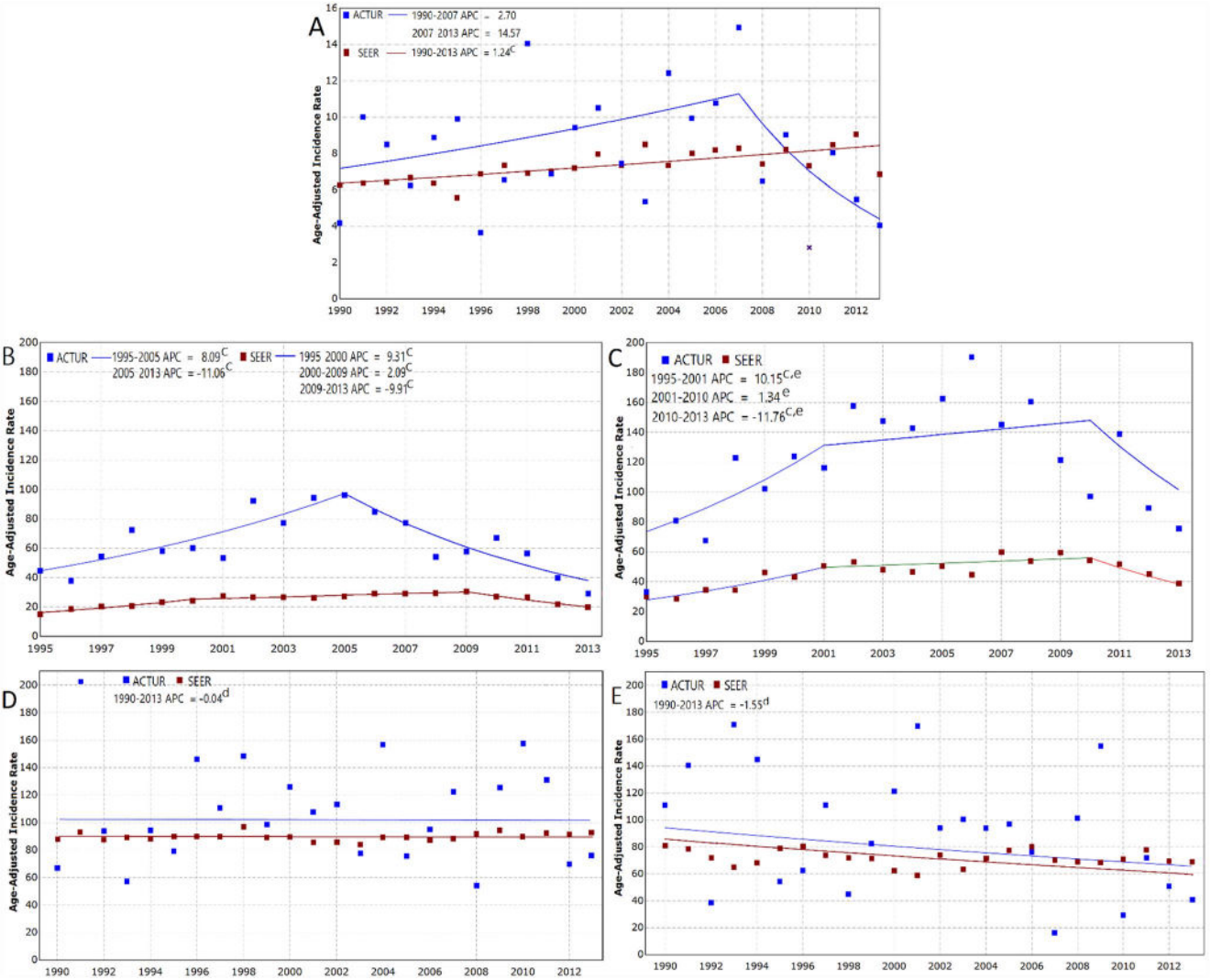

FIGURE 2 Trends in age-adjusted incidence rates[a] of local staged colorectal (1990–2013),[b] prostate (1995–2013), and breast cancers (1990–2013) among individuals 40–59 years old in the US active-duty (ACTUR) and the general US (SEER) populations. (A) Colorectal cancer incidence trends among White men. (B) Prostate cancer incidence trends among White men. (C) Prostate cancer incidence trends among Black men. (D) Breast cancer incidence trends among White women. (E) Breast cancer incidence trends among Black women. [a]All incidence rates were adjusted to the active-duty military population. [b]Trends for colorectal cancer in Black men were not calculated due to small annual sample sizes. [c]Indicates the annual percentage change is significantly different than zero. [d]The two trends are statistically equivalent. [e]The two trends are statistically parallel.

individuals,[26–28] and persons ages 50+ might be more likely to be screened than persons in the general population. It has been reported that the military has equivalent or higher rates of cancer screening than the civilian population.[7–10] Thus, cancer screening may partially account for the higher rates of localized breast and prostate cancers among 40- to 59-year-olds and for higher rates of localized colorectal cancers among 50- to 59-year-olds in the military. Additionally, servicemembers may receive greater medical surveillance due to free care, which could lead to higher incidence of localized tumors. Higher cumulative exposure to risk factors may also contribute to higher incidence of prostate and breast cancers among active-duty 40- to 59-year-olds than their civilian counterparts.[29,30] Servicewomen may have occupational exposure to chemicals associated with breast cancer incidence.[21] Servicewomen are also more likely to have used hormonal contraceptives and less likely to have breast-fed,[31–33] both of which are risk factors of breast cancer.

Prostate and breast cancer trends were both driven by local staged tumors among White persons 40–59 years old. Incidence rates among the military were higher in all time periods for local staged prostate cancer and most periods for local staged breast cancer. Because this is the age recommended for cancer screening, incidence trends might reflect the effects of screening. Trends were more pronounced for breast cancer among 50- to 59-year-olds, the ages at which individuals were more likely to have received recommended mammograms. Decreased incidence of localized prostate cancer before 2013 in both populations generally coincided with

national trends, which suggested the effects of prostate cancer screening recommendation changes.[34] For colorectal cancer, the subgroups analysis for localized cancer among White men 40–59 years old showed similar trends as those in the group of 20- to 59-year-olds with all tumor stages for both populations, probably as a result of including younger individuals (40–49 years old), an age range not routinely recommended for colorectal screening during the time frame of this study.[35,36] Lung cancer trends were similar between populations; however, rates were much lower in the military at all time points for distant stage tumors. This may be related to higher accessibility to medical care and therefore earlier diagnosis in the military.

This study had several strengths. Compared with the previous study, a larger population allowed analyses by age and cancer stage in addition to race and sex. We also used a robust Joinpoint Regression model to estimate and compare temporal trends. Nonetheless, our study had limitations. First, we were unable to exclude potential cancer under-reporting within ACTUR from small military treatment facilities with limited manpower, or cancers diagnosed and treated outside the military health system. However, higher incidence rates of some cancers in ACTUR than SEER in this study and others[11,19,37] suggest the effects of underreporting might be limited. Second, it is possible that case consolation processes might vary between ACTUR and SEER, which could contribute to differences. Third, low numbers of cancers among women and Black persons precluded some subgroup analyses. Fourth, we were unable to distinguish Hispanic and non-Hispanics persons in the analysis as ethnicity information is less complete in ACTUR. Thus, we cannot exclude an effect of ethnicity on the results. Fifth, in general, cancer registry data do not contain data on etiologic factors and therefore we were unable to examine differences in risk factors. Finally, we could not exclude that some servicemembers were included in both ACTUR and SEER data, but this is unlikely given there are no data-sharing agreements between the military and SEER and servicemembers form a small percent of the overall population.

Our current results provide updated evidence for differences in cancer incidence between the military and general populations and may reflect the potential effects of free medical care, cancer screening, healthiness, and/or cumulative environmental exposures. Further research is warranted to investigate factors associated with differences in cancer incidence between the military and general populations.

AUTHOR CONTRIBUTIONS

Julie A. Bytnar: Conception, methodology, investigation, data analysis, interpretation, and writing–review. **Katherine A. McGlynn**: Data analysis, interpretation, and writing–review. **Matthew D. Nealeigh**: Data analysis, interpretation, and writing–review. **Craig D. Shriver** Conception, methodology, investigation, data analysis, interpretation, funding, and writing–review. **Kangmin Zhu**: Conception, methodology, investigation, data analysis, interpretation, study supervision, and writing–review.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data from the Department of Defense's Joint Pathology Center cannot be shared publicly because they are third party data and do not belong to the authors. Interested researchers can contact the Joint Pathology Center (https://www.jpc.capmed.mil/education/dodccrs/reseachers.asp).

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