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Thyroid Cancer Incidence among Active Duty U.S. Military Personnel, 1990–2004

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Abstract

Background: Increases in thyroid papillary carcinoma incidence rates have largely been attributed to heightened medical surveillance and improved diagnostics. We examined papillary carcinoma incidence in an equal-access health care system by demographics that are related to incidence.

Methods: Incidence rates during 1990–2004 among white and black individuals aged 20 to 49 years in the military, and the general U.S. population were compared using data from the Department of Defense's Automated Central Tumor Registry and the National Cancer Institute's Surveillance Epidemiology and End Results (SEER-9) program.

Results: Incidence was significantly higher in the military than in the general population among white women [incidence rate ratio (IRR) = 1.42; 95% confidence interval (CI), 1.25–1.61], black women (IRR = 2.31; 95% CI, 1.70–2.99), and black men (IRR = 1.69, 95% CI, 1.10–2.50). Among whites, differences between the two populations were confined to rates of localized tumors (women: IRR = 1.73, 95% CI, 1.47–2.00; men: IRR = 1.51, 95% CI, 1.30–1.75), which may partially be due to variation in staging classification. Among white women, rates were significantly higher in the military regardless of tumor size and rates rose significantly over time both for tumors ≤ 2 cm (military: IRR = 1.64, 95% CI, 1.18–2.28; general population: IRR = 1.55, 95% CI, 1.45–1.66) and > 2 cm (military: IRR = 1.74, 95% CI, 1.07–2.81; general population: IRR = 1.48, 95% CI, 1.27–1.72). Among white men, rates increased significantly only in the general population. Incidence also varied by military service branch.

Conclusions: Heightened medical surveillance does not appear to fully explain the differences between the two populations or the temporal increases in either population.

Impact: These findings suggest the importance of future research into thyroid cancer etiology. *Cancer Epidemiol Biomarkers Prev*; 20(11); 2369–76. ©2011 AACR.

Introduction

The American Cancer Society estimated that 48,020 new cases of thyroid cancer would be diagnosed in the United States during 2011 (1). About 75% of these cases were expected to occur among females, making it the fifth most common cancer among women (1). Thyroid cancer incidence rates among whites is almost twice that among

blacks (2) and is one of the most common cancers among young adults (3).

The incidence rate of thyroid cancer has been rising in the United States and other developed countries over the past 3 decades (4–11). Greater temporal increases have been observed among women than among men and among whites than among blacks (11). The increases have predominantly been among small (≤ 2 cm) papillary carcinomas, leading many to believe that trends are largely an artifact resulting from the use of better diagnostic tools (6, 12). However, rates have also increased for larger tumors, suggesting that there may also be a true increase in thyroid cancer incidence due to changes in risk factors (11, 13). The etiology of thyroid cancer is still poorly understood; the only major, well-established risk factor is radiation exposure.

Thyroid cancer among active duty military personnel is an important issue, given that it occurs at a relatively young age, especially among women. Studying incidence rate patterns among military personnel, who may have different exposures than the general population, may

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provide guidance in developing future etiologic studies. In addition, because the Military Health System is an equal access health care system serving an ethnically diverse population, it provides a unique opportunity to study diagnoses that are potentially related to health care access and utilization. The current study compared the incidence rate of papillary carcinoma, the histologic type that represents the majority of thyroid cancers, and the most rapid increases from 1990 to 2004 among active duty military personnel using the Department of Defense's (DoD) Automated Central Tumor Registry (ACTUR) and among the general U.S. population using data from the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) program.

Methods

Papillary carcinoma incidence data among active duty personnel aged 20 to 49 years were obtained from the ACTUR, which was established in 1986 and is the data collection and clinical tracking system for all cancer cases diagnosed or treated at military treatment facilities among DoD beneficiaries (active duty, retirees, and dependents). For the purposes of this study, data for active duty patients diagnosed from 1990 to 2004 were included. Although all data submitted to the ACTUR are reviewed and verified for accurate diagnoses, data prior to 1990 were not included, to minimize the possibility of incomplete recording. Procedures, which have been previously described (14), were developed using national and state cancer registry guidelines (15, 16) to identify and consolidate duplicate records so that only one record existed for each primary cancer. The annual population counts of active duty personnel were obtained from the Defense Manpower Data Center, which maintains demographic and military data on personnel in all military services. Dependents and retirees were excluded because the population at risk for these groups could not be determined.

Cases were originally categorized using the International Classification of Diseases for Oncology (ICD-O), ICD-O-1 (17) for cases diagnosed during 1990–1991, ICD-O-2 (18) for cases diagnosed during 1992–2000, and ICD-O-3 (19) for cases diagnosed after 2000. Codes for all cases diagnosed before 2001 were converted to ICD-O-3 according to SEER guidelines. Thyroid papillary carcinoma was defined using the ICD-O topographic (C73) and morphologic codes (8050, 8260, 8340–8344, 8350, 8450, 8452, and 8460; ref. 20). Demographic and tumor characteristics were obtained for each case. Stage at diagnosis was determined by SEER Summary Stage (21). When there were multiple records per tumor at the time of diagnosis and the tumor stage codes differed, determination of stage was based on surgery records if available. If no surgery records were available, the most advanced stage noted was selected. The same record was then used to determine tumor size based on the combination of 2 variables: "Extent of Disease Collaborative Stage (EOD) 10 size" (diagnosis years: 1990–2003) and "CS tumor size" (diagnosis year: 2004; ref. 21).

For comparison, papillary carcinoma incidence data among individuals aged 20 to 49 years in the general U.S. population were obtained from the SEER program, which began consolidating data from selected U.S. cancer registries in 1973, using the same inclusion criteria as described earlier for the ACTUR data. Papillary carcinoma incidence and population counts from 1990 to 2004 were obtained from the original 9 SEER registries: Atlanta, Connecticut, Detroit, Hawaii, Iowa, New Mexico, San Francisco–Oakland, Seattle–Puget Sound, and Utah (22). These registries represent approximately 10% of the U.S. population. Stage at diagnosis was determined according to "SEER Historic Stage A." The stage classifications differed slightly in the ACTUR and SEER populations: Tumors that had spread "into or through thyroid capsule, but not beyond" were considered localized by the SEER Summary Stage in ACTUR but regional by SEER Historic Stage A in SEER (23). Tumor size was based on the same variables in SEER as in ACTUR.

Analyses were restricted to whites and blacks because the numbers were small for other racial/ethnic groups in the military. Stratified analyses by age, tumor stage, and size were conducted only among whites because of limited sample sizes among blacks in the military. Although single-year age was available in both populations, age was assessed using a binary variable, which was dichotomized at 35 years (the midpoint of the included age range), to ensure ample sample sizes. For trend analysis, years of diagnosis were grouped into 2 categories: 1990–1997 and 1998–2004. There were very few distant/unstaged ($n = 19$) papillary carcinomas among whites in the military; therefore, trend analyses by stage were conducted only for localized and regional tumors. Adjusted rates, incidence rate ratios (IRR), and their 95% confidence intervals (CI) were calculated by the Tiwari method (24). To give more weight to the age groups with a large number of active duty members and thereby minimize variability, all rates were age adjusted on the basis of the distribution of the combined active duty military population from 1990 to 2004 using six 5-year age groups (20–49 years) and were expressed per 100,000 person-years. The significance level was specified as $P < 0.05$. All calculations were completed with SAS statistical software, version 9.1 (SAS Institute Inc.; ref. 24).

The study used deidentified data and was approved by the Institutional Review Boards of U.S. Military Cancer Institute, Armed Forces Institute of Pathology, and National Cancer Institute, NIH.

Results

From 1990 to 2004, among whites and blacks, there were 743 papillary carcinomas diagnosed in the military (ACTUR data) and 11,930 diagnosed in the general population (SEER data; Table 1). In both populations, rates were higher among whites than among blacks and

Table 1. Incidence rates of papillary thyroid cancer in the U.S. active duty military and U.S. general populations (age 20–49) by select characteristics, 1990–2004

Characteristic	Women				Men				Women to men ratio		
	Military (ACTUR)		General population (SEER-9)		Military (ACTUR)		General population (SEER-9)		Military (ACTUR)	General population (SEER-9)	
	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 ^c (95% CI)	
All	333	13.66 (12.23–15.23)	9,562	10.25 (10.00–10.51)	410	2.35 (2.12–2.59)	2,368	2.21 (2.10–2.32)	1.06 (0.95–1.19)	5.82 (4.93–6.75)	4.65 (4.39–4.91)
Race											
White	261	16.22 (14.30–18.33)	9,002	11.39 (11.09–11.68)	366	2.62 (2.36–2.90)	2,269	2.42 (2.30–2.55)	1.08 (0.96–1.21)	6.20 (5.13–7.29)	4.70 (4.43–4.98)
Black	72	8.95 (6.98–11.33)	560	3.87 (3.50–4.28)	44	1.30 (0.94–1.76)	99	0.77 (0.60–0.97)	1.69 (1.10–2.50)	6.86 (4.21–10.29)	5.03 (3.92–6.54)
Age ^d											
20–34	173	10.07 (8.62–11.70)	3,564	7.67 (7.40–7.95)	178	1.30 (1.12–1.51)	733	1.46 (1.35–1.57)	0.89 (0.75–1.05)	7.74 (5.94–9.61)	5.26 (4.84–5.73)
35–49	88	6.15 (4.93–7.57)	5,438	3.71 (3.60–3.83)	188	1.32 (1.13–1.52)	1,536	0.97 (0.91–1.02)	1.36 (1.15–1.59)	4.67 (3.38–6.05)	3.85 (3.60–4.11)
Stage ^{e,f}											
Localized	191	11.99 (10.34–13.83)	5,847	6.94 (6.72–7.16)	239	1.70 (1.49–1.93)	1,144	1.13 (1.05–1.21)	1.51 (1.30–1.75)	7.04 (5.54–8.55)	6.16 (5.69–6.68)
Regional	65	3.91 (3.01–5.00)	2,810	3.95 (3.77–4.13)	113	0.81 (0.68–0.98)	975	1.12 (1.04–1.21)	0.72 (0.58–0.89)	4.82 (3.19–6.61)	3.52 (3.21–3.86)
Size ^{g,h} , cm											
≤2	160	10.08 (8.58–11.79)	5,696	6.80 (6.58–7.02)	165	1.17 (1.00–1.37)	1,130	1.14 (1.06–1.23)	1.03 (0.86–1.22)	8.59 (6.44–10.75)	5.95 (5.49–6.45)
>2	79	4.78 (3.78–5.97)	2,392	3.41 (3.24–3.58)	150	1.08 (0.91–1.26)	805	0.91 (0.84–0.99)	1.18 (0.97–1.42)	4.44 (3.12–5.88)	3.73 (3.38–4.12)

^aAge-adjusted (active duty military 1990–2004 and six 5-year age groups) rates per 100,000 person-years.

^bIRR comparing rates in the military to the rates in the general population.

^cIRR comparing rates among men to rates among women in the same population.

^dAmong Whites only.

^eMilitary: SEER Summary Stage; General population: SEER Historic Stage A; distant and unknown stages were not included (military, 19; general population, 495).

^fUnknown size not included (military, 73; general population, 1,248).

among women than among men. Papillary carcinoma incidence rates in the military were significantly higher than in the general population among women of both races (white: IRR = 1.42, 95% CI, 1.25–1.61; black: IRR = 2.31, 95% CI, 1.70–2.99) and among black men (white: IRR = 1.69; 95% CI, 1.10–2.50) but not among white men (white: IRR = 1.08; 95% CI, 0.96–1.21). Given the small number of total papillary carcinomas among blacks in the military (men, 44; women, 72), further stratification was not possible. As a result, all subsequent analyses were limited to whites.

When stratified by sex and age, the incidence rate of papillary carcinoma in the military compared with the general population was significantly higher among women in both age groups and among older men. The incidence rates of localized tumors were significantly higher in the military than in the general population among both sexes (women: IRR = 1.73, 95% CI, 1.47–2.00; men: IRR = 1.51, 95% CI, 1.30–1.75). The incidence rate of regional tumors was significantly lower in the military than in the general population among men (IRR = 0.72; 95% CI, 0.58–0.89) but not among women. When stratified by sex and size, which was available for 554 (91%) of the cases in the military and 9,998 (93%) of the cases in the general population, rates among women were significantly higher in the military than in the general population (≤ 2 cm: IRR = 1.48, 95% CI, 1.25–1.74; >2 cm: IRR = 1.40, 95% CI, 1.08–1.76), but no significant difference was observed among men. The female to male IRR was 4.65 (95% CI, 4.39–4.91) in the general population overall and ranged from a low of 3.52 (95% CI, 3.21–3.86) for regional stage disease to 6.16 (5.69–6.68) for localized disease. Larger sex differences were observed in the military, with an IRR of 5.82 (95% CI, 4.93–6.75) overall and a range from 4.44 (3.12–5.88) for >2 -cm size tumors to 8.59 (95% CI, 6.44–10.75) for ≤ 2 -cm size tumors.

Temporal trends in papillary carcinoma incidence rates by sex in ACTUR and SEER are presented in Table 2. Among women, the incidence rate of papillary carcinoma remained higher in the military throughout the study period, and rates rose in both populations (military: IRR = 1.48, 95% CI, 1.14–1.90; general population: IRR = 1.40, 95% CI, 1.33–1.48). Significant increases among women were observed for both age groups, stages of disease, and tumor sizes in the general population and in the military population except among those aged 20 to 34 years in the military. The papillary carcinoma incidence rate among men increased significantly only in the general population from 1990–1997 to 1998–2004.

Papillary carcinoma incidence rates varied by military service branch (Table 3). Among men, the incidence (per 100,000) ranged from 1.62 in the Marines to 3.34 in the Air Force. Among women, the rate was highest in the Army (18.97), followed by the Air Force (17.71), and, finally, the Navy (11.32). There were insufficient numbers of women with papillary carcinoma in the Marines, Coast Guard, and the "Other" service branch to calculate stable rate estimates.

Discussion

In comparison with the general population, the age-adjusted incidence rate of papillary carcinoma among those aged 20 to 49 years was significantly higher in the military between 1990 and 2004 among black men and women of both races. Among whites, age-adjusted incidence rates in the military were significantly higher than in the general population among older men and women, regardless of age. Significantly higher rates of localized tumors were observed in the military for both sexes. When stratified by size, among women rates in the military were significantly higher regardless of size, but no significant differences were observed among men. Significant temporal increases in rates were observed among women in both populations and men in the general population despite stratification by age, tumor stage, and tumor size. Papillary carcinoma incidence rates might also vary by branch of military service.

Although the magnitude of the association was less extreme, our finding of higher papillary carcinoma incidence rates among U.S. military personnel is in agreement with an Italian study, which observed a 1- to 2-fold higher than expected standardized incidence ratio for thyroid cancer among Army servicemen who were deployed to Bosnia or Kosovo (25). However, the reasons for the higher incidence rate in the U.S. military than in the general population or the variation in rates by service branch are not clear. The etiology of papillary carcinoma is poorly understood. Ionizing radiation exposure is the major known risk factor (17). Although military personnel may have increased exposure to radiation, particularly from depleted uranium that is used in munitions and tank armor, an expert working group concluded that the excess cancer risk of such exposure is likely minimal (26). Military personnel may also have increased exposures to environmental chemicals, such as polychlorinated biphenyls (PCB), which have been positively correlated with thyroid-stimulating hormone levels (27), which, in turn, are positively associated with increased cell proliferation (28) and thus an increased opportunity for mutations promoting the development of cancer. Although PCBs have been found on older commissioned Navy vessels (29), differential exposure to PCBs between the military and general population does not appear to fully explain our findings because rates were lower in the Navy than in the other service branches. Exposure to polybrominated diphenyl ethers (PBDE), which are chemically similar to PCBs (30) and can also affect thyroid function (31), may also be related to the higher incidence rate in the military, particularly among Air Force personnel. PBDE levels have been shown to be elevated in airplane cabins and in postflight blood concentrations from passengers (32). However, in subsequent studies PBDE blood concentrations were not found to be related to time spent in an airplane among passengers (33) or commercial aviation workers (34). Other environmental or occupational exposures may differ both between the general population and the military and

Table 2. Incidence rates of papillary thyroid cancer among whites of age 20 to 49 in the U.S. active duty military and U.S. general populations by year of diagnosis, sex, and other select characteristics, 1990–2004

Characteristic	Population	1990–1997		1998–2004		IRR ^b (95% CI)
		Count	Rate ^a (95% CI)	Count	Rate ^a (95% CI)	
<i>Women</i>						
All	Military (ACTUR)	124	13.31 (11.06–15.89)	137	19.64 (16.45–23.27)	1.48 (1.14–1.90)
	General population (SEER-9)	3,904	9.62 (9.25–9.99)	5,098	13.51 (13.05–13.98)	1.40 (1.33–1.48)
Age						
20–34	Military (ACTUR)	95	9.68 (7.83–11.84)	78	10.68 (8.42–13.38)	1.10 (0.80–1.51)
	General population (SEER-9)	1,695	6.68 (6.35–7.04)	1,869	8.92 (8.50–9.36)	1.33 (1.24–1.43)
35–49	Military (ACTUR)	29	3.62 (2.42–5.22)	59	8.96 (6.80–11.57)	2.47 (1.55–4.01)
	General population (SEER-9)	2,209	2.93 (2.80–3.07)	3,229	4.59 (4.41–4.78)	1.57 (1.47–1.67)
Stage ^c						
Localized	Military (ACTUR)	94	10.14 (8.19–12.44)	97	14.16 (11.46–17.30)	1.40 (1.03–1.88)
	General population (SEER-9)	2,421	5.56 (5.29–5.84)	3,426	8.59 (8.24–8.96)	1.54 (1.45–1.65)
Regional	Military (ACTUR)	25	2.64 (1.71–3.91)	40	5.48 (3.90–7.51)	2.08 (1.21–3.59)
	General population (SEER-9)	1,259	3.45 (3.22–3.68)	1,551	4.55 (4.27–4.84)	1.32 (1.20–1.45)
Size ^d , cm						
≤2	Military (ACTUR)	72	7.77 (6.07–9.80)	88	12.77 (10.22–15.77)	1.64 (1.18–2.28)
	General population (SEER-9)	2,349	5.43 (5.17–5.71)	3,347	8.44 (8.08–8.80)	1.55 (1.45–1.66)
>2	Military (ACTUR)	34	3.61 (2.50–5.08)	45	6.28 (4.56–8.43)	1.74 (1.07–2.81)
	General population (SEER-9)	1,051	2.92 (2.72–3.14)	1,341	3.98 (3.72–4.25)	1.48 (1.27–1.72)
<i>Men</i>						
All	Military (ACTUR)	209	2.52 (2.19–2.89)	157	2.76 (2.34–3.22)	1.09 (0.88–1.35)
	General population (SEER-9)	992	2.08 (1.92–2.25)	1,277	2.83 (2.64–3.03)	1.36 (1.22–1.51)
Age						
20–34	Military (ACTUR)	103	1.23 (1.00–1.49)	75	1.42 (1.12–1.78)	1.16 (0.84–1.57)
	General population (SEER-9)	348	1.29 (1.15–1.44)	385	1.67 (1.50–1.86)	1.30 (1.11–1.52)
35–49	Military (ACTUR)	106	1.30 (1.06–1.57)	82	1.34 (1.07–1.66)	1.03 (0.76–1.39)
	General population (SEER-9)	644	0.79 (0.72–0.87)	892	1.16 (1.07–1.25)	1.46 (1.29–1.65)
Stage ^c						
Localized	Military (ACTUR)	131	1.58 (1.32–1.88)	108	1.88 (1.54–2.27)	1.19 (0.91–1.55)
	General population (SEER-9)	475	0.91 (0.81–1.02)	669	1.38 (1.25–1.52)	1.52 (1.31–1.76)
Regional	Military (ACTUR)	68	0.82 (0.64–1.04)	45	0.80 (0.58–1.07)	0.98 (0.65–1.44)
	General population (SEER-9)	440	0.99 (0.88–1.11)	535	1.28 (1.14–1.42)	1.29 (1.10–1.51)
Size ^d , cm						
≤2	Military (ACTUR)	90	1.08 (0.87–1.33)	75	1.30 (1.02–1.63)	1.19 (0.86–1.64)
	General population (SEER-9)	487	0.94 (0.84–1.05)	643	1.39 (1.25–1.53)	1.48 (1.27–1.72)
>2	Military (ACTUR)	81	0.98 (0.78–1.22)	69	1.23 (0.95–1.55)	1.25 (0.89–1.75)
	General population (SEER-9)	321	0.74 (0.64–0.84)	484	1.12 (0.99–1.25)	1.51 (1.26–1.80)

^aAge-adjusted (active duty military 1990–2004 and six 5-year age groups) rates per 100,000 person-years.

^bIRR comparing rates in 1998–2004 to the rates in 1990–1997.

^cMilitary: SEER Summary Stage; General population: SEER Historic Stage A; distant and unknown stages were not included (military, 19; general population, 495).

^dUnknown size not included (military, 73; general population, 1,248).

within the military by service branch. Unfortunately, occupational information was not available in the registry records and thus could not be investigated. Within the military, variations in occupation seem unlikely to fully explain the observed differences by sex and race. Previous studies have indicated that career field does not differ by sex or race/ethnicity among enlisted corps (35), which represents the majority of active duty personnel.

Additional suspected risk factors for thyroid cancer include increased body mass index (BMI) and height (36, 37), use of fertility drugs (38), changes in reproductive patterns (39, 40), immigration from high incidence countries (41), and insulin resistance syndrome (42). Given that military personnel tend to be healthier than the general population because they have to pass entrance and routine physical fitness tests (43, 44), many of these factors

Table 3. Incidence rates of papillary thyroid cancer among whites of age 20 to 49 years in the U.S. active duty military population by sex and service branch, ACTUR 1990–2004

	Women			Men		
	Count	Rate ^a (95% CI)	IRR (95% CI)	Count	Rate ^a (95% CI)	IRR (95% CI)
Army	77	18.97 (14.92–23.78)	1.00 (reference)	102	2.55 (2.08–3.10)	1.00 (Reference)
Navy	52	11.32 (8.44–14.88)	0.60 (0.41–0.86)	89	2.27 (1.82–2.80)	0.89 (0.66–1.20)
Air force	114	17.71 (14.60–21.29)	0.93 (0.69–1.27)	143	3.34 (2.81–3.95)	1.31 (1.01–1.71)
Marines	7	^b	^b	19	1.62 (0.95–2.57)	0.64 (0.35–1.06)
Coast guard	8	^b	^b	12	2.69 (1.38–4.75)	1.06 (0.48–1.94)
Other	3	^b	^b	1	^b	^b

^aAge-adjusted (active duty military 1990–2004 and six 5-year age groups) rates per 100,000 person-years.

^bRates were not calculated when counts were <10.

seem unlikely as explanations for our findings. Like other cancer registries, risk factor data were not available in this database; results from this descriptive study provide clues for future research on possible factors that may be related to the observed differences. Increased health care access and medical surveillance in the military may partially explain the higher incidence rates in the military, particularly because the higher rates in the military were observed for localized tumors only. However, caution should be taken when interpreting these findings because differential classification of tumors that had spread "into or through thyroid capsule, but not beyond" may be at least partially responsible for the observed differences. Although incidence rates tended to remain higher in the military when stratified by tumor size, the differences were significant only among women and were not confined to small tumors (≤ 2 cm); therefore, variations in medical surveillance cannot fully explain the differences between the 2 populations. Although we are unaware of any official recommendation or policy differences that are followed in the general population and the military or within the military by service branch, it is possible that screening practices for thyroid diseases do differ, which may partially account for the observed variations.

Heightened medical surveillance also does not appear to fully explain the temporal increases in either population because increases were observed regardless of stage or size among both sexes in the general population and among women in the military. One would expect more rapid increases in small early-stage tumors than large late-stage tumors if the increase was due to improved disease detection; subsequently, rates for larger more advanced tumors should decline. We did not observe declines in the incidence rates of larger more advanced tumors. Instead, we found that the incidence rates of tumors of all stages and sizes increased over time. It is not clear why no significant temporal increases were observed among men in the military, even though the use of medical diagnostic tools such as computed tomographic scans increased during the study period (45, 46). Data on patient presen-

tation or how the cancer was diagnosed (i.e., physical examination or imaging) were not available for the current study; future studies that assess these variables could help clarify how variations in medical surveillance contributed to findings of this study.

The relatively stable temporal incidence rate among white servicemen is likely the reason why the overall 1990–2004 incidence rate was not significantly different among white men in the military and the general population. During the first study period (1990–1997), the incidence rate was higher among white men in the military (2.52 per 100,000) than among those in the general population (2.08 per 100,000). Interestingly, the temporal increase in incidence rates among white women in the military and white men and women in the general population were similar (IRR range: 1.36–1.48). These findings provide evidence that exposures, risk factors, or even surveillance might have differed among white servicemen. Unfortunately, data were not available to help discern what factors could account for the different temporal pattern among white servicemen.

The reason for the disparities in papillary carcinoma incidence rates by sex is likely multifactorial. In addition to possible inherent sex differences, women may have more frequent and more thorough thyroid examinations because women have a higher tendency to use health care services and to be diagnosed with benign thyroid diseases (47, 48). Although we are unaware of any official policy that recommends increased screening for thyroid diseases, including cancer, among servicewomen, in practice this may occur. If a larger variation in screening practice between the sexes exists in the military, then this may partially explain the larger sex differences in incidence rates that were observed in the military compared with the general population. It is also possible that procedures and/or reporting may differ by service branch, which is related to sex and according to our findings possibly papillary carcinoma incidence. Furthermore, it cannot be excluded that sex differences in thyroid cancer risk factors may be larger in the military than in the general population.

This study had notable strengths in that it examined thyroid cancer, specifically papillary carcinoma, incidence rates across all military branches. However, there is the possibility of underreporting in the ACTUR. Although DoD policies require all cancers to be reported to the ACTUR, some small military treatment facilities might not have reported patients with cancer. The extent of underreporting in the military is unknown. Despite the possible underreporting in the military, the higher incidence rates in the military suggest that underreporting cannot explain the observed differences between the 2 populations. It is also possible that reporting may differ by service branch, which may partially explain the variation by service branch. As a result of including only active duty personnel, it is unclear whether the incidence rate patterns observed in this study can be generalized to individuals who were no longer active duty at the time of diagnosis. Some sample sizes in the military were also small, which limited our ability to calculate stable rates for all strata. Another possible study limitation is that the data consolidation procedures might differ between the ACTUR and SEER; no shared standards for case consolidation currently exist. However, our data consolidation procedures were developed on the basis of guidelines from the North America Association of Central Cancer Registries, SEER (15, 16), and state cancer registries; therefore, data consolidation differences may not be substantial enough to account for the observed variations.

In agreement with previous findings in other populations, the incidence rate of papillary carcinoma significantly increased among white servicewomen in the U.S. military between 1990 and 2004. Heightened medical surveillance does not appear to fully explain the differences between the 2 populations or the temporal patterns in either population; rates were not consistently higher in the military and the temporal increases among servicewomen and among both sexes in the general population

were observed regardless of tumor stage or size. Further insight into the etiology of thyroid papillary carcinoma may be gained by conducting more in-depth studies among military personnel, particularly servicewomen, who had higher incidence rates than women in the general population.

Disclosure of Potential Conflicts of Interest

We certify that all individuals who qualify as authors have been listed; each has participated in the conception and design of this work, the analysis of data, the writing of the document, and the approval of the submission of this version; that the document represents valid work; that if we used information derived from another source, we obtained all necessary approvals to use it and made appropriate acknowledgments in the document; and that each takes public responsibility for it. Nothing in the presentation implies any Federal/DoD/DoN endorsement. The views expressed in the article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Army, Department of Defense, nor the U.S. Government. Authors acknowledge that research protocol NNMC.2006.001C "Cancer Frequencies: Analysis of the DoD Automated Central Tumor Registry Data" received applicable NNMC Institutional Review Board review and approval.

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