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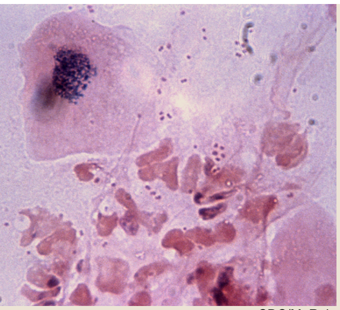

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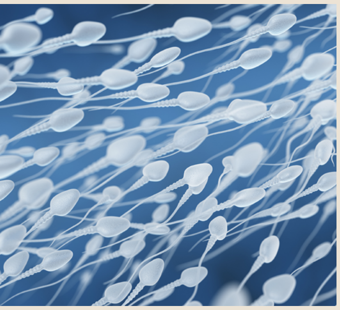

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Sexually Transmitted Infections, Active Component, U.S. Armed Forces, 2010–2018

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This report summarizes incidence rates of the 5 most common sexually transmitted infections (STIs) among active component service members of the U.S. Armed Forces during 2010–2018. Infections with chlamydia were the most common, followed in decreasing order of frequency by infections with genital human papillomavirus (HPV), gonorrhea, genital herpes simplex virus (HSV), and syphilis. Compared to men, women had higher rates of all STIs except for syphilis. In general, compared to their respective counterparts, younger service members, non-Hispanic blacks, soldiers, and enlisted members had higher incidence rates of STIs. During the latter half of the surveillance period, the incidence of chlamydia and gonorrhea increased among both male and female service members. Rates of syphilis increased for male service members but remained relatively stable among female service members. In contrast, the incidence of genital HPV and HSV decreased among both male and female service members. Similarities to and differences from the findings of the last *MSMR* update on STIs are discussed.

WHAT ARE THE NEW FINDINGS?

The incidence of chlamydia and gonorrhea increased among male and female service members in the latter half of the surveillance period, while the incidence of genital HPV and HSV decreased. Among male service members, the incidence of syphilis increased sharply between 2012 and 2018.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

STIs can adversely impact service members' availability and ability to perform their duties and can result in serious medical sequelae if untreated. Establishing standards for screening, testing, treatment, and reporting would likely improve efforts to detect STI-related health threats. Continued behavioral risk-reduction interventions are needed to counter the increasing incidence of STIs among service members.

Sexually transmitted infections (STIs) are relevant to the U.S. military because of their relatively high incidence, adverse impact on service members' availability and ability to perform their duties, and potential for serious medical sequelae if untreated.[1] Two of the most common bacterial STIs are *Chlamydia trachomatis* (chlamydia) and *Neisseria gonorrhoeae* (gonorrhea). Rates of chlamydia and gonorrhea have been steadily increasing in the general U.S. population among both men and women since 2000.[2] A September 2017 *MSMR* report documented almost 180,000 incident infections of chlamydia and more than 29,000 incident infections of gonorrhea among active component U.S. military members between 2007 and 2016, with no overall decrease in incidence rates during the 10-year period.[3]

Another important bacterial STI is syphilis, which is caused by the bacterium *Treponema pallidum*. Rates of primary and secondary syphilis in the U.S. increased 72.7%, from 5.5 cases per 100,000 persons in 2013 to 9.5 cases per 100,000 persons in 2017.[2] These trends are mirrored in the active component of the U.S. Armed Forces, in which the incidence of syphilis (of any type) doubled between 2007 and 2016, with most of the increase occurring among men.[3] Although these 3 relatively common bacterial STIs are curable with antibiotics, there is continued concern regarding the threat of multidrug resistance.[4]

Common viral STIs in the U.S. include infections caused by human papillomavirus (HPV) and genital herpes simplex virus (HSV). HPVs are DNA viruses that infect basal epithelial (skin or mucosal) cells. HPV genotypes 6 and 11 are responsible for 90% of all genital wart infections.[5] HSV can cause genital or oral herpes infections that are characterized by the appearance of 1 or more vesicles that can break and leave painful ulcers. Most genital herpes infections are caused by type 2 (HSV-2); however, type 1 (HSV-1), which is most often associated with oral herpes infection, is estimated to be responsible for 50% of new genital herpes infections.[6] Neither HPV nor HSV viral infections are curable with antibiotics; however, suppression of recurrent herpes manifestations is attainable using antiviral medication, and there is a vaccine to prevent infection with 4 of the most common HPV serotypes. From 2007 through 2016, the overall incidence rates of genital HPV and HSV in the active component were 60.1 and 23.3 cases per 10,000 person-years (p-yrs), respectively.[3]

The current analysis updates the findings of previous *MSMR* articles on STIs among active component service members.[1,3] Specifically, the current report summarizes incident cases and incidence rates of 5 of the most common STIs among active component military members during 2010–2018 by demographic and military characteristics.

METHODS

The surveillance period was 1 January 2010 through 31 December 2018. The surveillance population consisted of all active component service members of the U.S. Army, Navy, Air Force, or Marine Corps who served at any time during the period. Diagnoses of STIs were ascertained from medical administrative data and reports of notifiable medical events routinely provided to the Armed Forces Health Surveillance Branch and maintained in the Defense Medical Surveillance System for surveillance purposes. STI cases were also derived from positive laboratory records in the Health Level 7 (HL7) chemistry and microbiology databases maintained by the Navy and Marine Corps Public Health Center at the EpiData Center.

For each service member, the number of days in active military service was ascertained and then aggregated into a total for all service members during each calendar year. The resultant annual totals were expressed as p-yrs of service and used as the denominators for the calculation of annual incidence rates. Person-time that was not considered to be time at risk for each STI was excluded (i.e., the 30 days following each incident chlamydia or gonorrhea infection and all person-time following the first diagnosis, medical event report, or positive laboratory test of HSV, HPV, or syphilis).

An incident case of chlamydia was defined by having any of the following: 1) a case-defining diagnosis **(Table 1)** in the first or second diagnostic position of a record of an outpatient or in-theater medical encounter, 2) a confirmed notifiable disease report for chlamydia, or 3) a positive laboratory test for chlamydia (any specimen source or test type). An incident case of gonorrhea was similarly defined by having 1) a case-defining diagnosis in the first or second diagnostic position of a record of an inpatient or outpatient or in-theater encounter, 2) a confirmed notifiable disease report for gonorrhea, or 3) a positive laboratory test for gonorrhea (any specimen source or test type). For both chlamydia and gonorrhea, an individual could be counted as having a subsequent case only if there were more than 30 days between the dates on which the case-defining diagnoses were recorded.

Incident cases of HSV were identified by 1) the presence of the requisite ICD-9 or ICD-10 codes in either the first or second diagnostic positions of a record of an outpatient or in-theater encounter or 2) a positive laboratory test from a genital specimen source. Antibody tests were excluded because they do not allow for distinction between genital and oral infections. Incident cases of HPV were similarly identified by 1) the presence of the requisite ICD-9 or ICD-10 codes in either the first or second diagnostic positions of a record of an outpatient or in-theater encounter or 2) a positive laboratory test from any specimen source or test type. Outpatient encounters for HPV with evidence of an immunization for HPV within 7 days before or after the encounter date were excluded as were outpatient encounters with a procedural or Current Procedural Terminology (CPT) code indicating HPV vaccination, as such encounters were potentially related to the vaccination administration. An individual could be counted as an incident case of HSV or HPV only once during the surveillance period. Individuals who had diagnoses of HSV or HPV infection prior to the surveillance period were excluded from the analysis.

An incident case of syphilis was defined by having 1) a qualifying ICD-9 or ICD-10 code in the first, second, or third diagnostic position of a hospitalization, 2) at least 2 outpatient or in-theater encounters within 30 days of each other, with a qualifying ICD-9 or ICD-10 code in the first or second position, 3) a confirmed notifiable disease report for any type of syphilis, or 4) a record of a positive polymerase chain reaction or treponemal laboratory test. Stages of syphilis (primary, secondary, late, latent) could not be distinguished because the HL7 laboratory data do not allow for differentiation of stages and because there is a high degree of misclassification associated with the use of ICD diagnosis codes for stage determination.[7,8] An individual could be considered an incident case of syphilis only once during the surveillance period; those with evidence of prior syphilis infection were excluded from the analysis.

TABLE 1. ICD-9 and ICD-10 diagnostic codes used to identify cases of STIs in electronic healthcare records

Name of STI	ICD-9[a]	ICD-10[a]
Genital HPV	078.11, 079.4, 795.05, 795.09, 795.15, 795.19, 796.75, 796.79	A63.0, R85.81, R85.82, R87.81, R87.810, R87.811, R87.82, R87.820, R87.821, B97.7
Chlamydia	099.41, 099.5*	A56.*
Genital HSV	054.1*	A60.*
Gonorrhea	098.*	A54.*
Syphilis	091.*, 092.*, 093.*–096.*, 097.0, 097.1, 097.9	A51.* (excluding A51.31), A52.*, A53.0, A53.9

[a]An asterisk (*) indicates that any subsequent digit/character is included
HSV, herpes simplex virus; HPV, human papillomavirus

RESULTS

Between 2010 and 2018, the number of incident chlamydia infections among active component service members was greater than that of any other single STI and approximately 3 times the total number of genital HPV infections—the next most frequently identified STI during this period **(Table 2)**. With the exception of syphilis, the overall incidence rates of all STIs were markedly higher among women than men. For chlamydia, gonorrhea, and syphilis, overall incidence rates were highest among those aged 24 years or younger and decreased with advancing age. However, overall rates of genital HSV and HPV were highest among those aged 20–24 years and those aged 25–29 years. Rates of all STIs were highest among non-Hispanic black service members compared to other race/ethnicity groups. For chlamydia, gonorrhea, and genital HSV, overall rates were

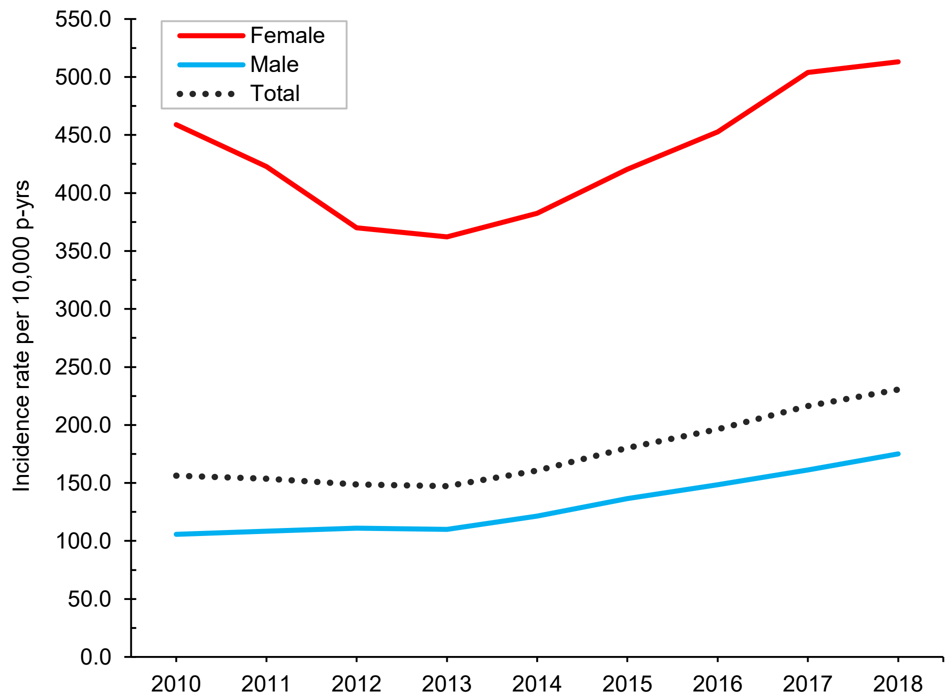
TABLE 2. Incident counts and incidence rates of STIs, active component, U.S. Armed Forces, 2010–2018

	Chlamydia		Gonorrhea		Syphilis		Genital HSV		Genital HPV	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total (2010–2018)	212,405	175.7	32,987	27.3	4,674	3.9	28,295	23.7	71,138	61.1
Sex										
Male	133,094	129.8	25,852	25.2	4,094	4.0	15,871	15.6	31,670	31.5
Female	79,311	432.5	7,135	38.8	580	3.2	12,424	70.3	39,468	250.2
Age group (years)										
<20	27,691	352.3	3,209	40.7	362	4.6	1,907	24.2	1,850	23.5
20–24	122,638	319.8	17,711	46.1	1,779	4.6	11,564	30.3	30,147	80.0
25–29	42,566	146.8	7,427	25.6	1,262	4.4	7,583	26.5	19,519	70.6
30–34	12,800	66.7	2,894	15.1	642	3.3	3,765	20.0	11,173	62.2
35–39	4,600	33.3	1,114	8.1	281	2.0	1,985	14.8	5,100	39.3
40+	2,110	16.7	632	5.0	348	2.8	1,491	12.0	3,349	27.5
Race/ethnicity										
Non-Hispanic white	86,681	120.7	8,972	12.5	1,613	2.2	13,434	18.9	37,935	54.7
Non-Hispanic black	70,371	362.2	17,395	89.3	1,703	8.8	8,324	43.9	14,546	78.8
Hispanic	33,841	205.9	3,917	23.8	854	5.2	3,989	24.6	10,619	67.3
Asian/Pacific Islander	6,759	146.7	836	18.1	154	3.3	640	14.0	2,287	51.2
Other/unknown	14,753	171.4	1,867	21.7	350	4.1	1,908	22.4	5,751	69.7
Service										
Army	92,167	200.6	17,262	37.5	1,890	4.1	12,567	27.7	27,289	61.5
Navy	48,546	168.4	7,392	25.6	1,557	5.4	6,550	23.0	17,647	63.7
Air Force	42,576	147.4	4,621	16.0	830	2.9	6,313	22.2	19,251	70.3
Marine Corps	29,116	169.3	3,712	21.6	397	2.3	2,865	16.8	6,951	41.2
Rank										
Junior enlisted (E1–E4)	159,952	303.5	23,557	44.6	2,747	5.2	15,363	29.3	37,804	72.9
Senior enlisted (E5–E9)	44,624	94.6	8,160	17.3	1,541	3.3	9,747	21.1	23,450	52.9
Junior officer (O1–O3)	6,614	57.0	965	8.3	225	1.9	2,122	18.5	7,331	65.7
Senior officer (O4–O10)	666	8.7	193	2.5	129	1.7	773	10.3	2,015	27.4
Warrant officer (W01–W05)	549	32.1	112	6.5	32	1.9	290	17.4	538	33.3
Education level										
High school or less	185,406	232.6	28,357	35.5	3,449	4.3	20,371	25.8	48,527	62.7
Some college	13,302	95.0	2,304	16.4	531	3.8	3,350	24.6	8,545	65.6
Bachelor's or advanced degree	11,081	45.6	1,935	8.0	621	2.6	4,042	16.9	12,399	53.5
Other/unknown	2,616	91.5	391	13.7	73	2.6	532	18.8	1,667	60.1
Marital status										
Single, never married	140,463	286.7	21,132	43.0	2,863	5.8	14,077	28.9	35,105	73.4
Married	58,842	88.6	9,945	15.0	1,559	2.3	11,363	17.4	29,300	46.1
Other/unknown	13,100	239.0	1,910	34.8	252	4.6	2,855	54.3	6,733	137.0
Military occupation										
Combat-specific[b]	24,237	138.0	4,063	23.1	412	2.3	2,906	16.7	6,574	38.2
Motor transport	9,332	264.0	1,759	49.7	248	7.0	987	28.2	2,619	76.3
Pilot/air crew	2,137	47.1	267	5.9	61	1.3	576	12.8	1,578	36.1
Repair/engineering	60,450	171.4	8,997	25.5	1,122	3.2	7,483	21.5	17,872	52.3
Communications/intelligence	53,127	202.2	9,180	34.9	1,194	4.5	7,897	30.7	19,458	78.4
Healthcare	15,603	146.8	2,277	21.4	478	4.5	3,022	29.0	9,265	93.1
Other/unknown	47,519	206.1	6,444	27.9	1,159	5.0	5,424	23.8	13,772	61.7

[a]Incidence rate per 10,000 p-yrs
[b]Infantry/artillery/combat engineering/armor
HSV, herpes simplex virus; HPV, human papillomavirus

highest among members of the Army. The overall incidence rate of syphilis was highest among Navy members, and the overall rate of genital HPV was highest among Air Force members. Compared to their respective counterparts, enlisted service members and those with lower levels of educational achievement tended to have higher overall rates for all STIs. Married service members had the lowest incidence rates of all 5 STIs compared to service members who were single and never married or of other/unknown marital status. Overall rates of chlamydia, gonorrhea, and syphilis were highest among those working in motor transport. In contrast, genital HPV rates were highest among those in healthcare occupations, and the highest rates of genital HSV were among those working in communications/intelligence, health care, or motor transport **(Table 2)**. Patterns of incidence rates over time for each specific STI are described in the subsections below.

FIGURE 1. Incidence rates of chlamydia infections, by sex, active component, U.S. Armed Forces, 2010–2018

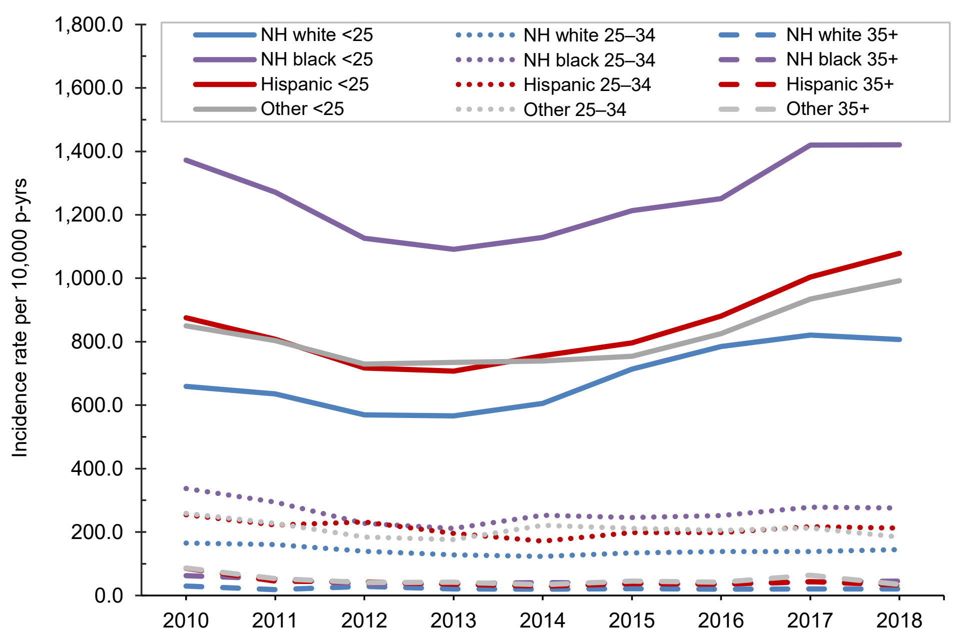


Chlamydia

During the surveillance period, annual incidence rates of chlamydia among service women generally ranged from 3 to 5 times the rates among men. Annual rates among men and women combined increased 56.6% between 2013 and 2018, with rates among both sexes peaking in 2018 (men: 175.1 per 10,000 p-yrs; women: 513.1 per 10,000 p-yrs) **(Figure 1)**. In both sexes, the increase was primarily attributed to service members in the youngest age groups (less than 25 years among women; less than 30 years among men) **(data not shown)**.

Among service women in each race/ethnicity group, annual rates of chlamydia increased among those under 25 years of age during 2013–2018 but remained relatively stable among those aged 25–34 years and among those aged 35 years or older **(Figure 2)**. Among service men, annual rates of chlamydia increased between 2013 and 2018 in all age and race/ethnicity groups less than 35 years old but remained relatively stable among those in older age groups **(Figure 3)**.

FIGURE 2. Incidence rates of chlamydia infections among females, by age group (years) and race/ethnicity, active component, U.S. Armed Forces, 2010–2018

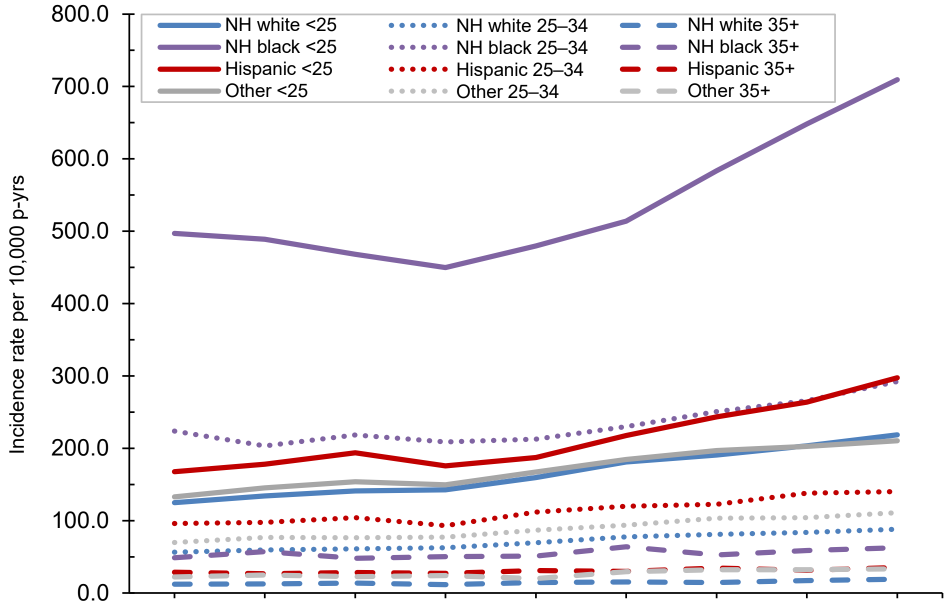


NH, non-Hispanic

Genital HPV

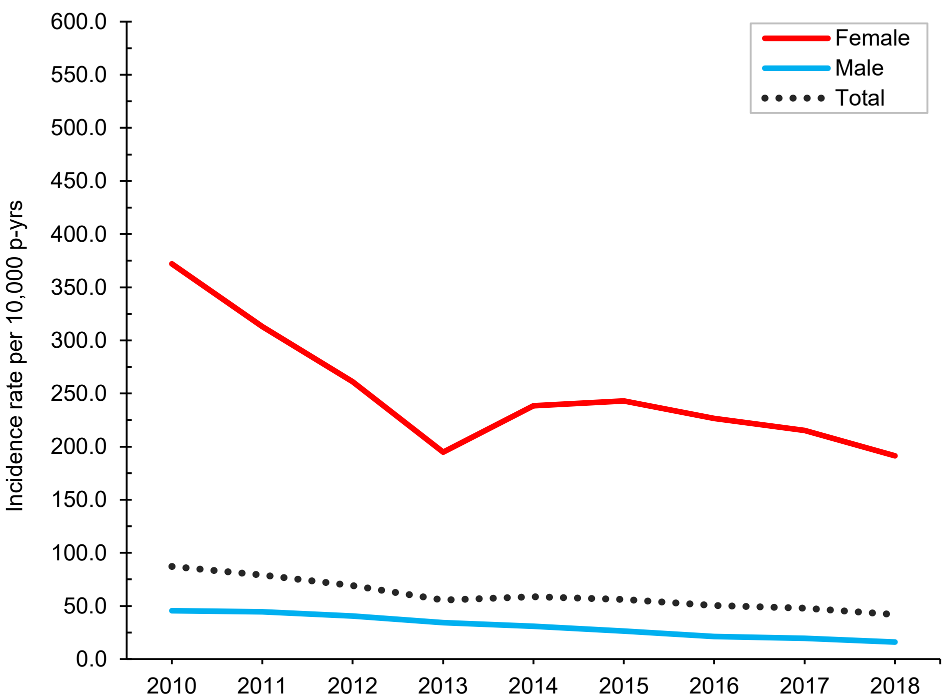
The annual incidence rates of diagnoses of genital HPV decreased 51.9% among all active component service members from the beginning to the end of the surveillance period, with the most dramatic decrease occurring among women **(Figure 4)**. There was a dip in the overall incidence of genital HPV in 2013 at 55.6 cases per 10,000 p-yrs, but the lowest point was reached in 2018 at 41.9 cases per 10,000

FIGURE 3. Incidence rates of chlamydia infections among males, by age group (years) and race/ethnicity, active component, U.S. Armed Forces, 2010–2018



NH, non-Hispanic

FIGURE 4. Incidence rates of genital HPV infections, by sex, active component, U.S. Armed Forces, 2010–2018



p-yrs. Incidence rates among female service members declined by almost 50% during the surveillance period, from a high of 372.1 cases per 10,000 p-yrs in 2010 to a low of 191.3 cases per 10,000 p-yrs in 2018 **(Figure 4).** Rates among men also decreased, from 45.5 per 10,000 p-yrs in 2010 to 16.0 per 10,000 p-yrs in 2018.

The decrease in the incidence among both men and women was attributable to a decrease in the rates in the youngest age groups (less than 30 years) **(Figures 5, 6).** Age-specific time trends were similar when stratified by race/ethnicity, in that the incidence of genital HPV decreased in the youngest age groups among service members in all race/ethnicity groups **(data not shown).**

Gonorrhea

Between 2012 and 2018, annual incidence rates of gonorrhea increased by 55.3% and 33.6% among male and female service members, respectively **(Figure 7).** The increase in gonorrhea incidence between 2012 and 2018 was primarily driven by increases among women less than 25 years of age and among men less than 30 years of age **(Figures 8, 9).** The ratio of the annual incidence rate for women compared to men was 2.1 in 2010 but dropped to 1.4 in 2018. The incidence of gonorrhea increased during the surveillance period among all race/ethnicities, with the sharpest increase occurring among non-Hispanic Black service members between 2015 and 2018 **(data not shown).** The incidence increased during the surveillance period among the youngest age groups for service members in all race/ethnicity groups **(data not shown).**

Genital HSV

Incidence rates of genital herpes infections decreased slightly from 25.3 to 20.4 per 10,000 p-yrs during the surveillance period. Rates among female service members ranged from a high of 74.8 per 10,000 p-yrs in 2010 to 64.0 per 10,000 p-yrs in 2018. Men's rates also peaked in 2010 (17.2 per 10,000 p-yrs) and reached their lowest point in 2018 (12.1 per 10,000 p-yrs) **(Figure 10).** Among women, the highest rates were observed among those less than 25 years of age, while the highest rates among men were among those aged 25–29 or 20–24 years **(data not shown).** The incidence of genital HSV decreased among all age groups during the surveillance period, although the sharpest decrease occurred

FIGURE 5. Incidence rates of genital HPV infections among females, by age group (years), active component, U.S. Armed Forces, 2010–2018

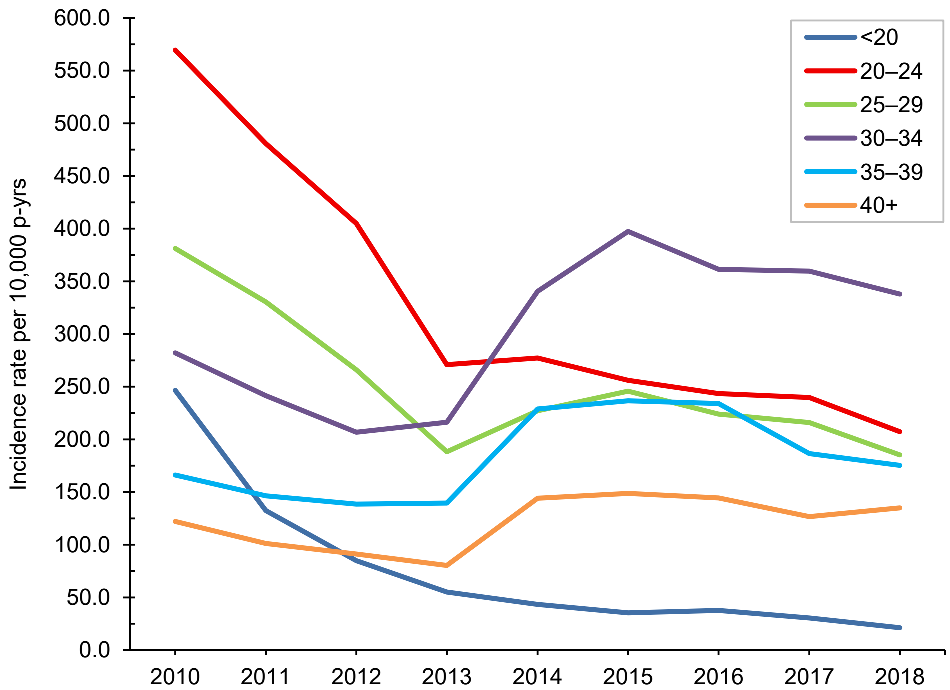
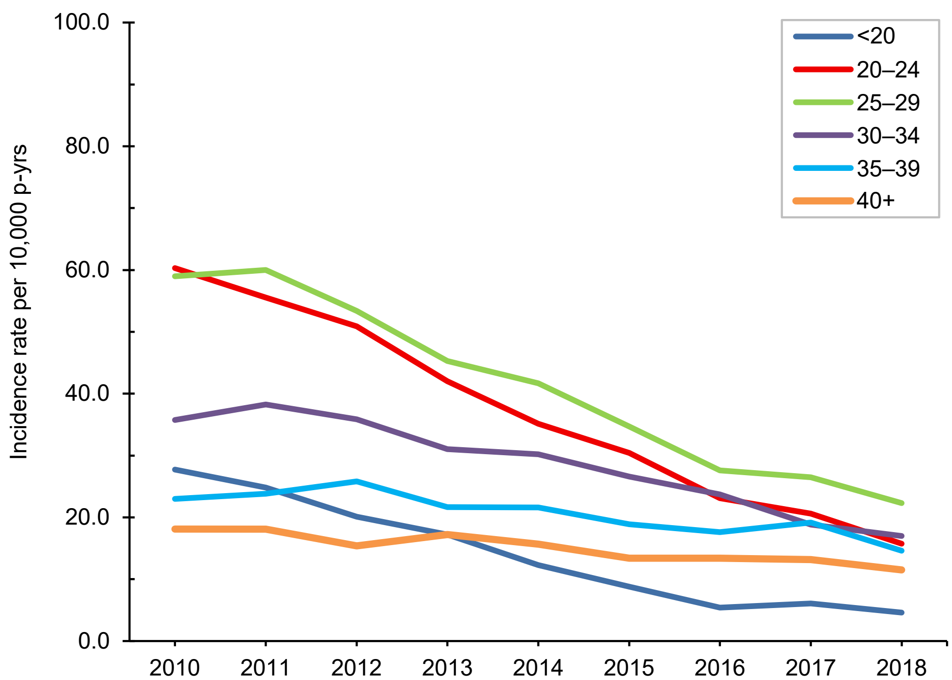


FIGURE 6. Incidence rates of genital HPV infections among males, by age group (years), active component, U.S. Armed Forces, 2010–2018



among service members aged 30 years and older **(data not shown)**. In addition, the incidence decreased among all race/ethnicities during the surveillance period except for Asian/Pacific Islanders. The decrease was most notable among non-Hispanic Black service members, who saw a decline from a high of 49.0 per 10,000 p-yrs in 2011 to a low of 37.4 per 10,000 p-yrs in 2018 **(data not shown)**.

Syphilis

The incidence rate for syphilis in the last year of the surveillance period was 2.7 times that observed in 2010, with the increase primarily driven by cases identified in male service members **(Figure 11)**. Rates of syphilis steadily increased among men during the surveillance period, with the sharpest increase occurring after 2012. Among women, rates increased from 2010 to 2014 but leveled off during the remainder of the surveillance period. The incidence of syphilis increased with advancing age among both men and women **(data not shown)**. Among men, the pattern of increasing incidence by age was consistent among all race/ethnicity groups; there were not enough cases to evaluate associations with age and race/ethnicity among women **(data not shown)**.

EDITORIAL COMMENT

During the last few years of the surveillance period, the annual incidence rates of chlamydia, gonorrhea, and syphilis increased among male service members, and the annual incidence of chlamydia and gonorrhea increased among female service members. Rates of syphilis remained relatively stable among female service members during the latter half of the surveillance period. In contrast, the incidence of genital HPV and HSV decreased among both male and female service members. Overall rates of STIs were higher among women when compared to men for HPV, HSV, gonorrhea, and chlamydia. Syphilis was the only STI in this analysis for which the incidence was, on average, higher among male compared to female service members.

Higher rates of most STIs among women can likely be attributed to implementation of the services' screening programs for STIs among female service members as they enter active service and during the subsequent annual screenings for women under age 26. Because asymptomatic infection with chlamydia, gonorrhea, or HPV is common among sexually active women, widespread screening may

FIGURE 7. Incidence rates of gonorrhea infections, by sex, active component, U.S. Armed Forces, 2010–2018

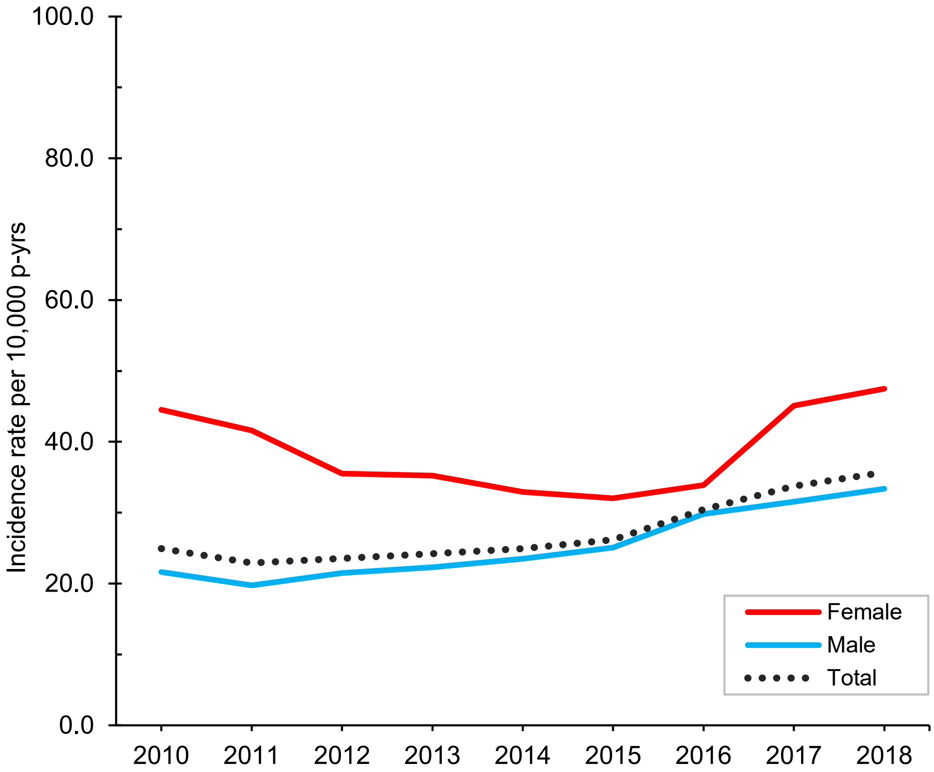
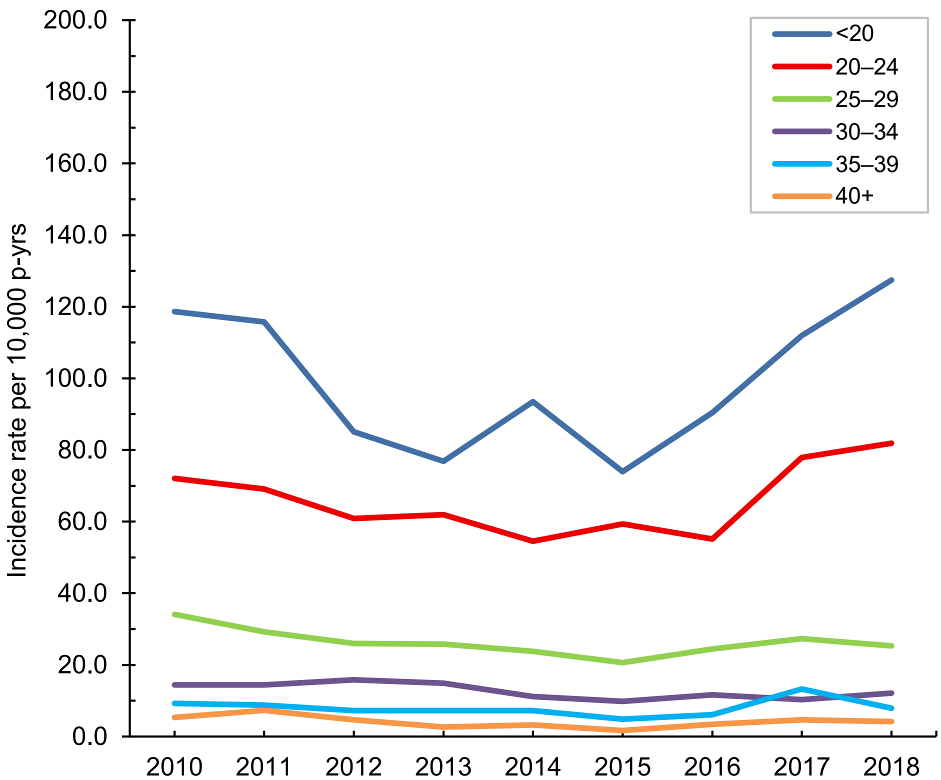


FIGURE 8. Incidence rates of gonorrhea infections among females, by age group (years), active component, U.S. Armed Forces, 2010–2018



result in sustained high numbers of infections diagnosed among young women. Rates of chlamydia and gonorrhea increased among both male and female service members during the latter half of the surveillance period. This trend is similar to the increasing rates in the civilian population. In the U.S., rates of chlamydia have been increasing among both men and women since 2000, and rates of gonorrhea have been increasing among both sexes since 2013.[2] These increases in both the civilian and military populations could reflect true increases in the incidence of infections as well as improved screening coverage in men, particularly extragenital screening in men who have sex with men.[9]

No data on sexual risk behaviors were available in this study, but prior surveys of military personnel have indicated high levels of risk behaviors. The 2015 Department of Defense Health Related Behaviors Survey (HRBS) documented that 19.4% of respondents reported having more than 1 sex partner in the past year and that 36.7% reported sex with a new partner in the past year without using a condom; these percentages were almost double those reported from the previous survey in 2011.[10] A pattern of continued increases in such reported risk behaviors would further suggest a true increase in the incidence of STIs like chlamydia and gonorrhea; however, data from the 2018 HRBS were not available at the time of this report.

The downward trend in genital HPV incidence rates observed during the surveillance period may be related to the introduction of the HPV vaccine for women and girls in 2006 and for men in 2010. Among civilian women aged 14–24 years, cervical/vaginal prevalence of HPV types 6, 11, 16, and 18 decreased by approximately 6% from the period 2003–2006 to 2009–2012.[8] The HPV vaccine is currently not a mandatory vaccine for military service, but it is encouraged and offered to service members. Because the HPV vaccine (Gardasil®) is approved for use among males and females beginning at age 11 years, it is possible that an increasing number of members who entered military service during the surveillance period may have been vaccinated for HPV prior to entering service. This prior vaccination may account for the

FIGURE 9. Incidence rates of gonorrhea infections among males, by age group (years), active component, U.S. Armed Forces, 2010–2018

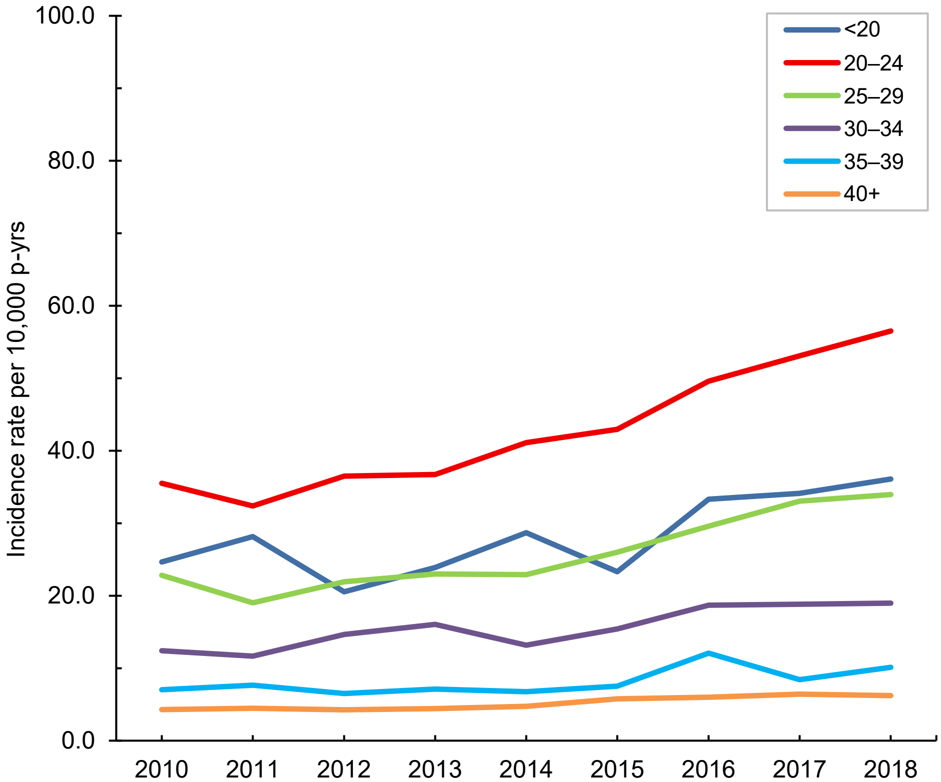
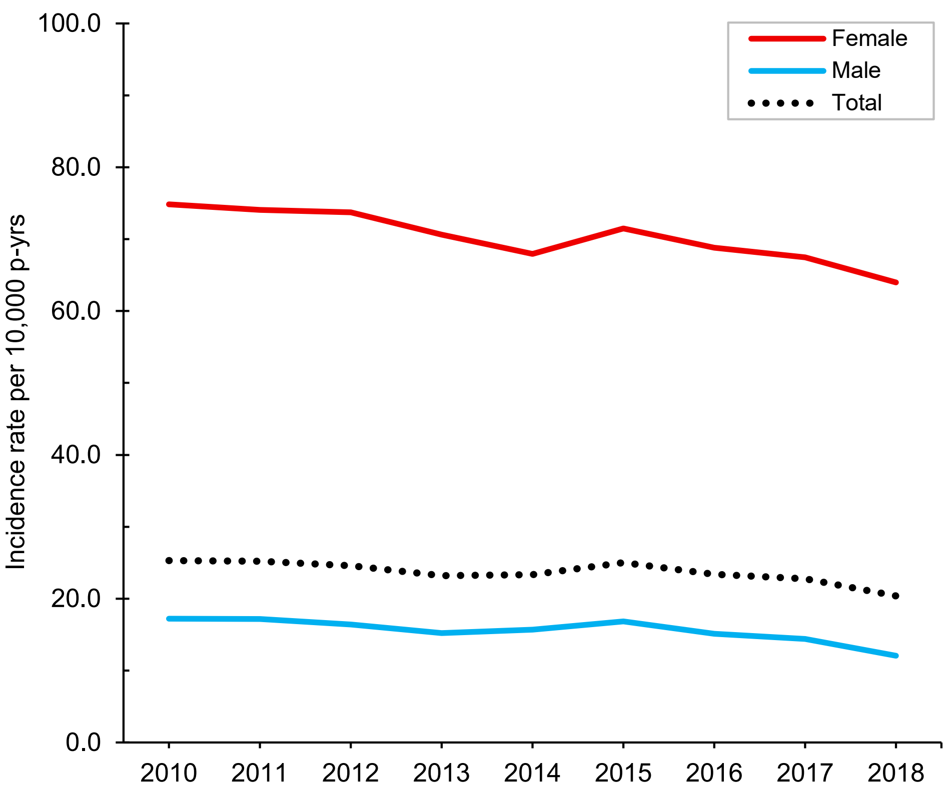


FIGURE 10. Incidence rates of genital HSV infections, by sex, active component, U.S. Armed Forces, 2010–2018



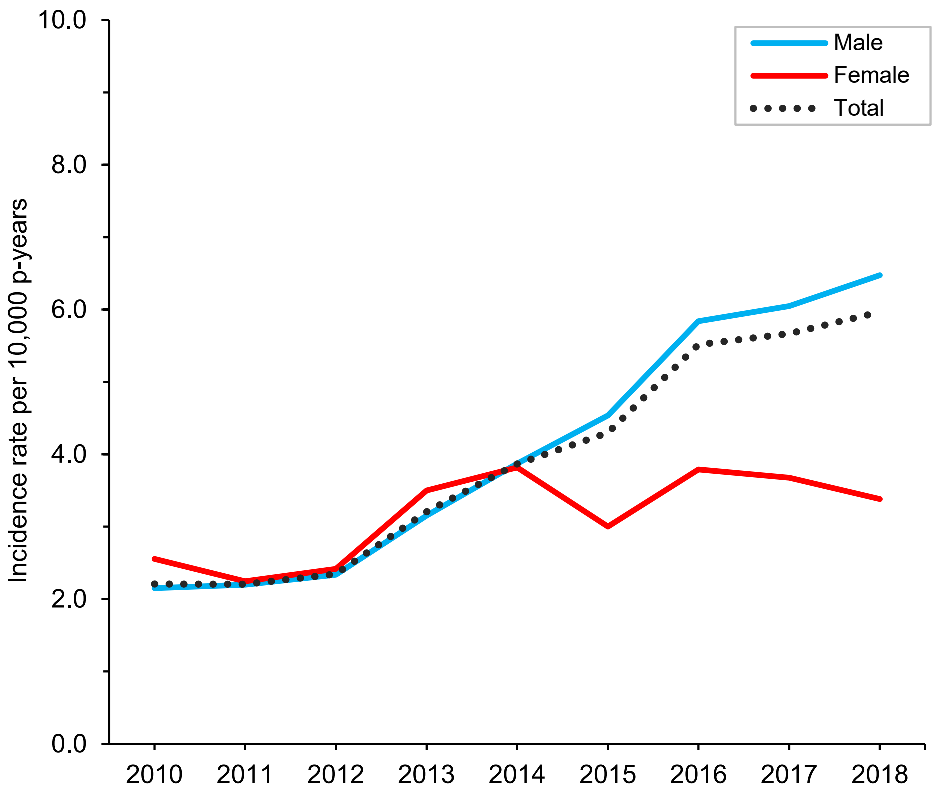
decrease in genital HPV incidence during the surveillance period even as the number of service women initiating HPV vaccine is decreasing.[11] However, the reason for the increased incidence of genital HPV after 2013 among women aged 30 years and older is unknown.

The trends in the incidence of HSV and syphilis in the U.S. military are also similar to what is observed in the civilian population. Data from the Centers for Disease Control and Prevention's (CDC's) National Health and Nutrition Examination Survey indicate that the seroprevalence of both HSV-1 and HSV-2 has decreased in the U.S. population since 1999.[2] In contrast, the incidence of primary and secondary syphilis reported to the CDC has increased markedly since 2001, with men accounting for the majority of cases.[2,12]

This report has several limitations that should be considered when interpreting the results. First, the results presented here are not comparable with the prior *MSMR* update on STIs because the case definition employed in the 2017 analysis did not include the results of laboratory tests for any of the STIs. In addition, the case definition for syphilis was revised for the current analysis to limit misclassification of diagnoses recorded during outpatient encounters and of diagnoses by syphilis stage.[7,8] However, diagnoses of STIs may still be incorrectly coded. For example, STI-specific "rule out" diagnoses or vaccinations (e.g., HPV vaccination) may be reported with STI-specific diagnostic codes, which would result in an overestimate of STI incidence. Cases of syphilis, genital HSV, and genital HPV based solely on laboratory test results are considered "suspect" because the lab test results cannot distinguish between active and chronic infections. However, because incident cases of these STIs were identified based on the first qualifying encounter or laboratory result, the likelihood is high that most such cases are acute and not chronic.

STI cases may not be captured if coded in the medical record using symptom codes (e.g., urethritis) rather than STI-specific codes. In addition, the counts of STI diagnoses reported here may underestimate the actual numbers of diagnoses because some affected service members may be

FIGURE 11. Incidence rates of syphilis by sex, active component, U.S. Armed Forces, 2010–2018



diagnosed and treated through non-reimbursed, non-military care providers (e.g., county health departments or family planning centers) or in deployed settings (e.g., overseas training exercises, combat operations, or aboard ships). Laboratory tests that are performed in a purchased care setting, a shipboard facility, a battalion aid station, or an in-theater facility were not captured in the current analysis.

For some STIs, the detection of prevalent infections may occur long after the initial infections. As a result, changes in incidence rates reflect, at least in part, temporal changes in case ascertainment, such as a shift to more aggressive screening. The lack of standard practices across the services and their installations regarding screening, testing, treatment, and reporting complicate interpretations of differences between services, military and demographic subgroups, and locations. Establishing screening, testing, treatment, and reporting standards across the services and ensuring adherence to such standards would likely improve efforts to detect and characterize STI-related health threats. In addition, continued behavioral risk-reduction interventions are needed to counter the increasing incidence of STIs among military service members.

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Vasectomy and Vasectomy Reversals, Active Component, U.S. Armed Forces, 2000–2017

Valerie F. Williams, MA, MS; Saixia Ying, PhD; Shauna Stahlman, PhD, MPH

During 2000–2017, a total of 170,878 active component service members underwent a first-occurring vasectomy, for a crude overall incidence rate of 8.6 cases per 1,000 person-years (p-yrs). Among the men who underwent incident vasectomy, 2.2% had another vasectomy performed during the surveillance period. Compared to their respective counterparts, the overall rates of vasectomy were highest among service men aged 30–39 years, non-Hispanic whites, married men, and those in pilot/air crew occupations. Male Air Force members had the highest overall incidence of vasectomy and men in the Marine Corps, the lowest. Crude annual vasectomy rates among service men increased slightly between 2000 and 2017. The largest increases in rates over the 18-year period occurred among service men aged 35–49 years and among men working as pilots/air crew. Among those who underwent vasectomy, 1.8% also had at least 1 vasectomy reversal during the surveillance period. The likelihood of vasectomy reversal decreased with advancing age. Non-Hispanic black and Hispanic service men were more likely than those of other race/ethnicity groups to undergo vasectomy reversals.

WHAT ARE THE NEW FINDINGS?

During 2000–2017, 170,878 service men underwent vasectomies (rate: 8.6 cases per 1,000 p-yrs). Annual rates increased 34% during the period. Rates were highest among men who were aged 30–39 years, non-Hispanic white, married, or in the Air Force. A total of 3,134 (1.8%) men underwent vasectomy reversal procedures. Younger men were more likely to seek reversals.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Vasectomy is a safe, simple, economical, and effective method of permanent contraception. Usually performed on an outpatient basis, vasectomies have a minimal impact on readiness. Service men's choice of vasectomy should be decided with medical personnel who can provide counsel about the factors important in deciding on permanent sterilization, such as age, number of children, and long term impact.

In the U.S., vasectomy is performed less often than female sterilization despite it being a safer, simpler, more economical, and equally effective option for permanent contraception.[1] U.S. data from the 2006–2010 National Survey for Family Growth (NSFG) estimated that 6.6% of men aged 15–44 years reported having had a vasectomy; this proportion increased with age, reaching up to 16% among men aged 36–45 years.[2] This prevalence estimate is relatively unchanged from the 2002 NSFG estimate of 6.2%.[3,4] However, these survey-based estimates are limited by a low response rate and sample size.[4,5] Results of U.S. studies using claims data show that the prevalence of vasectomies decreased from 2007 through 2015 among men aged 18–64 years with employer-based insurance, and prevalence estimates decreased across all age groups and in all locations of the country.[5,6] The incidence of vasectomy in the U.S. is poorly characterized. However, 1 retrospective survey-based study conducted in 2002 using a random sample of urologists, family physicians, and general surgeons from the American Medical Association Physician Masterfile yielded an annual vasectomy incidence rate of approximately 10 per 1,000 men aged 25–49 years.[7]

The vasectomy procedure involves isolation and interruption or occlusion of each vas deferens (vas) and is most typically performed in an outpatient setting.[5] The 2 most common surgical techniques for accessing/isolating the vas during vasectomy are the conventional method and minimally invasive techniques (including the no-scalpel vasectomy technique).[8] The conventional vasectomy (CV) technique is an open-style procedure that involves the use of a scalpel to make 1 midline incision or bilateral incisions on the scrotum.[9] Incisions are usually 1.5–3.0 cm in length, and no special instruments are used during CV.[7,9] Minimally invasive vasectomy (MIV) techniques use a percutaneous entry into the scrotum employing a sharp, forceps-like instrument.[9] MIV includes any vas isolation procedure that incorporates 2 key surgical principles—small (<10 mm) openings in the scrotal skin (either as a single midline opening or as bilateral openings) and minimal dissection of the vas and perivasal tissues using a vas ring clamp and vas dissector or similar special instruments.[8] After isolation, the vas is cut, cauterized, tied, or occluded using clips or occlusive implants.[9] In the U.S., nearly all vasectomy techniques use complete division of the vas with or without excision of a segment of the vas.[7] The available evidence indicates that a minimally invasive vas isolation procedure results in a significantly lower risk of postoperative complications (e.g., bleeding, postoperative pain, or infection) than CV.[10] In addition, there are no significant differences in the effectiveness (azoospermia or absence of motile sperm) of the 2 procedures.[10] The most recent (2012) American Urological Association guideline proposed as a standard that isolation of the vas should be performed using an MIV technique.[8]

Vasectomy reversal prevalence and trends in the general U.S. population are not well described. Results of studies conducted during the past 25 years indicate that up to 6% of men who undergo surgical sterilization will seek vasectomy reversal later.[11-13] Vasectomy reversal procedures include vasovasostomy and the more technically challenging vasoepididymostomy.[14] Vasovasostomy involves the reconnection of segments of the vas above and below an obstruction.[14] Vasoepididymostomy involves connection of the vas to the epididymis in order to bypass an epididymal obstruction.[14] Limited data are available on vasectomy reversal procedure patterns in the U.S.[15]

There are few published studies of vasectomy and vasectomy reversal among the U.S. military population. One administrative data-based study described the incidence of vasectomy and the demographic characteristics of U.S. active duty male service members aged 18–50 years who received vasectomies during 2000–2009.[16] This study searched the Career History Archival Medical and Personnel System database for all records with an ICD-9 diagnosis code for vasectomy. The overall incidence of vasectomy was 7.1 per 1,000 service men, with an age-adjusted overall rate of 8.7 per 1,000 service men.[16] A subsequent study using the same data source focused on the correlates of vasectomy reversal among the same group of vasectomized military members.[17] Among the service men who had vasectomies, approximately 5% underwent subsequent vasectomy reversal.[17] However, the published incidence estimate from this study did not appear to include percutaneous ligation vasectomies.[16,17] Moreover, the vasectomy reversal-focused study used only 1 Current Procedural Terminology (CPT) code to identify vasovasostomies; vasoepididymostomies were not included in the analysis. Neither study described the incidence of vasectomy by military characteristics.[16,17]

To address these gaps, the current analysis describes the overall and annual incidence rates of vasectomy among active component service men during 2000–2017 by demographic and military characteristics. In addition, the median age at incident vasectomy and the time between incident vasectomy and first vasectomy reversal are described.

METHODS

The surveillance period was 1 January 2000 through 31 December 2017. The surveillance population included all men who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. Diagnoses were ascertained from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System (MHS) or civilian facilities in the purchased care system documented in the Defense Medical Surveillance System (DMSS).

Vasectomies were defined by inpatient or outpatient medical encounters with a qualifying procedural code for the interruption/ligation of the vas coded in any position **(Table 1)**. The incident date was the date of the first qualifying medical encounter. An individual was considered as having had an incident vasectomy once per lifetime. However, men could be counted as having a repeat vasectomy once per year in the years following their incident vasectomy. Men who had their first vasectomy prior to the start of the surveillance period were excluded from the analysis. If multiple encounters occurred on the same incident date, inpatient encounters were prioritized over outpatient. Incidence rates were calculated as incident vasectomies per 1,000 person-years (p-yrs). Median age at incident vasectomy was computed overall and by race/ethnicity group. The distribution of incident vasectomy counts by location (facility and installation name) also was examined. In addition, the number of incident vasectomy cases who underwent subsequent/repeat vasectomies during the surveillance period was computed.

Vasectomy reversals were identified among men who underwent an incident vasectomy during the surveillance period, and reversals were similarly defined by inpatient or outpatient medical encounters with a qualifying procedural code in any position **(Table 2)**. Men could be counted as having repeated vasectomy reversals once per year in the years following their incident vasectomy. Vasectomy reversals were categorized as vasovasostomy (CPT code 55400; PR codes 63.81, 63.82, 63.84, 63.85, 63.89, 0VQJ*, 0VQK, 0VQL*, 0VQN*, 0VQP*, 0VQQ*, or OVPR*) or vasoepididymostomy (CPT codes 54900, 54901; PR codes 63.83, 0V1N*, 0V1P*, or 0V1Q*). The number of unique individuals who had 1 reversal and the number who had 2 or more reversals was determined from among the incident vasectomy cases who underwent vasectomy reversals. In addition, the time between incident vasectomy and first vasectomy reversal was examined by age group.

RESULTS

Vasectomy

During 2000–2017, a total of 170,878 active component service members underwent a first-occurring vasectomy, for a crude overall incidence rate of 8.6 cases per 1,000 p-yrs **(Table 3)**. The vast majority of these vasectomies were performed during outpatient encounters (n=170,601; 99.8%). More than four-fifths (n=145,721; 85.3%) of incident vasectomies took place in military treatment facilities (MTFs) compared with 14.7% in non-military medical facilities (outsourced care). Among the 170,878 men who underwent incident vasectomy, 3,729 (2.2%) had another vasectomy performed during the surveillance period. Of the men who underwent repeated vasectomies, 37 had more than 1 repeated vasectomy **(data not shown)**.

The crude overall incidence of vasectomy was highest among men aged 35–39 years (18.8 per 1,000 p-yrs) and those aged 30–34 years (18.4 per 1,000 p-yrs) **(Table 3)**. The overall incidence was highest among non-Hispanic white service men (9.5 per 1,000 p-yrs) and lowest among Asian/Pacific Islanders (4.8 per 1,000 p-yrs). Overall rates were similar among Hispanic

TABLE 1. Procedural codes used to identify vasectomy

Inpatient procedural codes			
ICD-9	Description	ICD-10	Description
63.73	Vasectomy	0VBN*	Excision of right vas
		0VBP*	Excision of left vas
		0VBQ*	Excision of bilateral vas
		0VTN*	Resection of right vas
		0VTP*	Resection of left vas
		0VTQ*	Resection of bilateral vas
63.71	Ligation of vas	0VLN*	Occlusion of right vas
		0VLP*	Occlusion of left vas
		0VLQ*	Occlusion of bilateral vas
Outpatient CPT codes			
55250	Vasectomy, unilateral or bilateral (separate procedure), including postoperative semen examination(s) [conventional incisional]		
55450	Ligation (percutaneous) of vas, unilateral or bilateral (separate procedure) [minimally invasive/no-scalpel]		

TABLE 2. Procedural codes used to identify vasectomy reversal

Inpatient procedural codes			
ICD-9	Description	ICD-10	Description
63.81	Suture of laceration of vas and epididymis	0VQJ*	Repair right epididymis
63.82	Reconstruction of surgically divided vas	0VQK*	Repair left epididymis
63.84	Removal of ligature from vas	0VQL*	Repair bilateral epididymis
63.89	Other repair of vas and epididymis	0VQN*	Repair right vas
63.83	Epididymovasostomy	0VQP*	Repair left vas
63.85	Removal of valve from vas	0VQQ*	Repair bilateral vas
		0V1N*	Bypass right vas to right epididymis
		0V1P*	Bypass left vas to left epididymis
		0V1Q*	Bypass bilateral vas to epididymis
		0VPR0DZ	Removal of intraluminal device from vas, open approach
		0VPR3DZ	Removal of intraluminal device from vas, percutaneous approach
		0VPR4DZ	Removal of intraluminal device from vas, percutaneous endoscopic approach
		OVPR7DZ	Removal of intraluminal device from vas, via natural or artificial opening
		OVPR8DZ	Removal of intraluminal device from vas, via natural or artificial opening endoscopic
		0VPRXDZ	Removal of intraluminal device from vas, external approach
Outpatient CPT codes			
55400	vasovasostomy, vasovasorrhaphy [VV]		
54900	epididymovasostomy, unilateral (vasoepididymostomy [VE])		
54901	epididymovasostomy, bilateral (vasoepididymostomy [VE])		

service men (7.7 per 1,000 p-yrs), those with other/unknown race/ethnicities (7.0 per 1,000 p-yrs), and non-Hispanic black service men (7.0 per 1,000 p-yrs). Married service men had the highest overall incidence of vasectomy (15.1 per 1,000 p-yrs) relative to men with other or unknown marital statuses (7.1 per 1,000 p-yrs) and those who were single and never married (0.5 per 1,000 p-yrs) **(Table 3)**. Compared with their respective counterparts, men serving in the Air Force had the highest overall incidence of vasectomy (10.6 per 1,000 p-yrs) and men in the Marine Corps had the lowest (5.7 per 1,000 p-yrs). Among the different ranks, incidence of vasectomy was highest among senior officers (18.5 per 1,000 p-yrs) and lowest among junior enlisted service men (2.3 per 1,000 p-yrs). Across military occupations, overall incidence rates of vasectomy were highest among service men in pilot/air crew occupations (15.0 per 1,000 p-yrs) and lowest among those working in motor transport (6.6 per 1,000 p-yrs) or other/unknown (6.9 per 1,000 p-yrs) occupations.

The median age at incident vasectomy was 32 years (interquartile range [IQR]=29–37) **(data not shown)**. Crude comparisons of age at incident vasectomy by race/ethnicity group showed that Hispanic service men had the youngest median age at vasectomy (median=31 years; IQR=28–36), while Asian/Pacific Islander service men had the oldest median age at vasectomy (median=35 years; IQR=30–39). Median age at incident vasectomy was similar among service men who were non-Hispanic white (median=32 years; IQR=29–37), non-Hispanic black (median=33 years, IQR=29–37), or of other/unknown race/ethnicity (median=32 years; IQR=29–36) **(data not shown)**.

Over the course of the surveillance period, annual incidence rates of vasectomy increased slightly from 7.8 cases per 1,000 p-yrs in 2000 to 10.4 cases per 1,000 p-yrs in 2017 (34.2% increase). During the first 10 years of the period, crude annual incidence rates of vasectomy fluctuated between 6.3 and 8.8 per 1,000 p-yrs **(Figure 1)**. Annual rates of vasectomy reached their lowest point in 2010 at 5.8 per 1,000 p-yrs, after which rates increased to

TABLE 3. Incident cases and incidence rates[a] of surgical vasectomy by demographic and military characteristics, active component, U.S. Armed Forces, 2000–2017

	Total 2000–2017	
	No.	Rate
Total	170,878	8.58
Setting		
Inpatient	277	0.01
Outpatient	170,601	8.57
Care type		
Direct care	145,721	7.32
Outsourced care	25,157	1.26
Age group (years)		
<20	211	0.08
20–24	8,687	1.59
25–29	43,840	9.63
30–34	53,899	18.42
35–39	42,662	18.82
40–49	21,076	12.01
50+	503	2.91
Race/ethnicity		
Non-Hispanic white	119,745	9.52
Non-Hispanic black	21,345	6.97
Hispanic	17,536	7.66
Asian/Pacific Islander	3,572	4.79
Other/unknown	8,680	6.99
Marital status		
Single, never married	4,135	0.49
Married	162,066	15.05
Other/unknown	4,677	7.11
Service		
Army	69,547	9.41
Navy	35,587	7.21
Air Force	48,420	10.59
Marine Corps	17,324	5.73
Rank		
Junior enlisted (E1–E4)	21,018	2.32
Senior enlisted (E5–E9)	106,769	13.81
Junior officer (O1–O3; W1-W3)	21,505	10.99
Senior officer (O4–O10; W4-W5)	21,586	18.45
Military occupation		
Combat-specific[b]	23,921	7.43
Motor transport	4,139	6.62
Pilot/air crew	12,047	14.96
Repair/engineering	54,181	8.64
Communications/ intelligence	36,620	9.22
Healthcare	14,342	11.10
Other/unknown	25,628	6.87

[a]Rate per 1,000 p-yrs
[b]Infantry/artillery/combat engineering/armor

10.1 per 1,000 p-yrs in 2012. After 2012, annual rates of vasectomy leveled off and remained between 10.3 and 10.6 per 1,000 p-yrs through the end of the surveillance period. In 2017, the annual rate of incident vasectomy performed in non-military facilities (2.1 per 1,000 p-yrs) was more than 5 times the rate in 2000 (0.4 per 1,000 p-yrs) **(Figure 1)**. By age group, the largest increases over the 18-year period were seen among service men aged 35–39 years (117.8%) and among those aged 40–49 years (158.4%). Among service men in the youngest age group (<20 years), annual vasectomy rates were low and relatively stable **(Figure 2)**.

Throughout the surveillance period, annual rates of vasectomy among non-Hispanic white service men were consistently higher than rates among service men in the other race/ethnicity groups **(Figure 3)**. From 2012 through 2017, annual vasectomy rates plateaued among Hispanic and Asian/Pacific Islander service men, with rates among non-Hispanic white service men and those of other/unknown race/ethnicity increasing slightly. Annual rates among non-Hispanic black service men decreased slightly between 2014 and 2017. During the surveillance period, annual rates of vasectomy increased slightly in each service **(Figure 4)**. Between 2002 and 2009, annual vasectomy rates were markedly higher among men in the Air Force than among men in the other services. During the surveillance period, annual rates of vasectomy increased slightly among service men in all military occupations except those working as pilot/air crew; pilot/air crew rates increased 140.7% over the course of the 18-year period (9.2 per 1,000 p-yrs in 2000 and 22.2 per 1,000 p-yrs in 2017) **(data not shown)**.

During the surveillance period, the largest number of incident vasectomies was performed at Naval Medical Center (NMC) Portsmouth, VA (n=7,726) **(Table 4)**. This was followed by NMC San Diego, CA (n=5,905), Fort Bragg, NC (n=5,900), and Fort Hood, TX (n=5,613). The locations outside of the U.S. with the largest number of incident vasectomies performed included Landstuhl, Germany (n=3,271), Okinawa, Japan (n=1,862), Seoul, South Korea (n=1,548), and Lakenheath, England (n=1,439) **(data not shown)**.

Vasectomy reversal

Among the 170,878 service men who underwent incident vasectomy, a total of 3,134 (1.8%) also had at least 1 vasectomy reversal during the surveillance period **(Table 5)**. Among these, 83 (2.6%) men had more than 1 vasectomy reversal **(data not shown)**. Vasectomy reversal was more common among men who had vasectomy performed during an inpatient stay (4.0%) compared with an outpatient encounter (1.8%). Among those who had their vasectomies performed at an MTF, 1.9% had a vasectomy reversal compared with 1.3% who had their vasectomy at an outsourced care facility **(Table 5)**.

During 2000–2017, the most common type of vasectomy reversal performed among active component service members was vasovasostomy (95.3% of total medical encounters for reversals; 95.2% of the total number of men affected) **(data not shown)**. A total of 3,006 service men had at least 1 vasovasostomy performed during the surveillance period, and 150 service men had at least 1 vasoepididymostomy performed during the surveillance period. A total of 80 service men had 2 vasectomy reversals, and 3 had 3 reversals **(data not shown)**. Of the 3,134 men who underwent vasectomy and subsequent vasectomy reversal during the surveillance period, nearly two-fifths (39.0%) had the reversal 6 or more years after the initial vasectomy and approximately one-quarter (25.1%) underwent vasectomy reversal 2–3 years after the initial vasectomy. A similar proportion (24.9%) of the men who underwent vasectomy reversal underwent the procedure 4–5 years after the initial vasectomy. Slightly more than one-tenth (11.1%) of the men who underwent vasectomy reversal did so less than 2 years after the initial vasectomy **(data not shown)**.

The likelihood of vasectomy reversal decreased with advancing age **(Table 5)**. Almost 5% of the service men who were less than 20 years of age at the time of incident vasectomy later underwent vasectomy reversal. A similar proportion (5.0%) of the service men aged 20–24 years at the time of vasectomy went on to receive vasectomy reversals compared with 3.1% of service members aged 25–29

FIGURE 1. Incidence rates of surgical vasectomy, by care type, active component, U.S. Armed Forces, 2000–2017

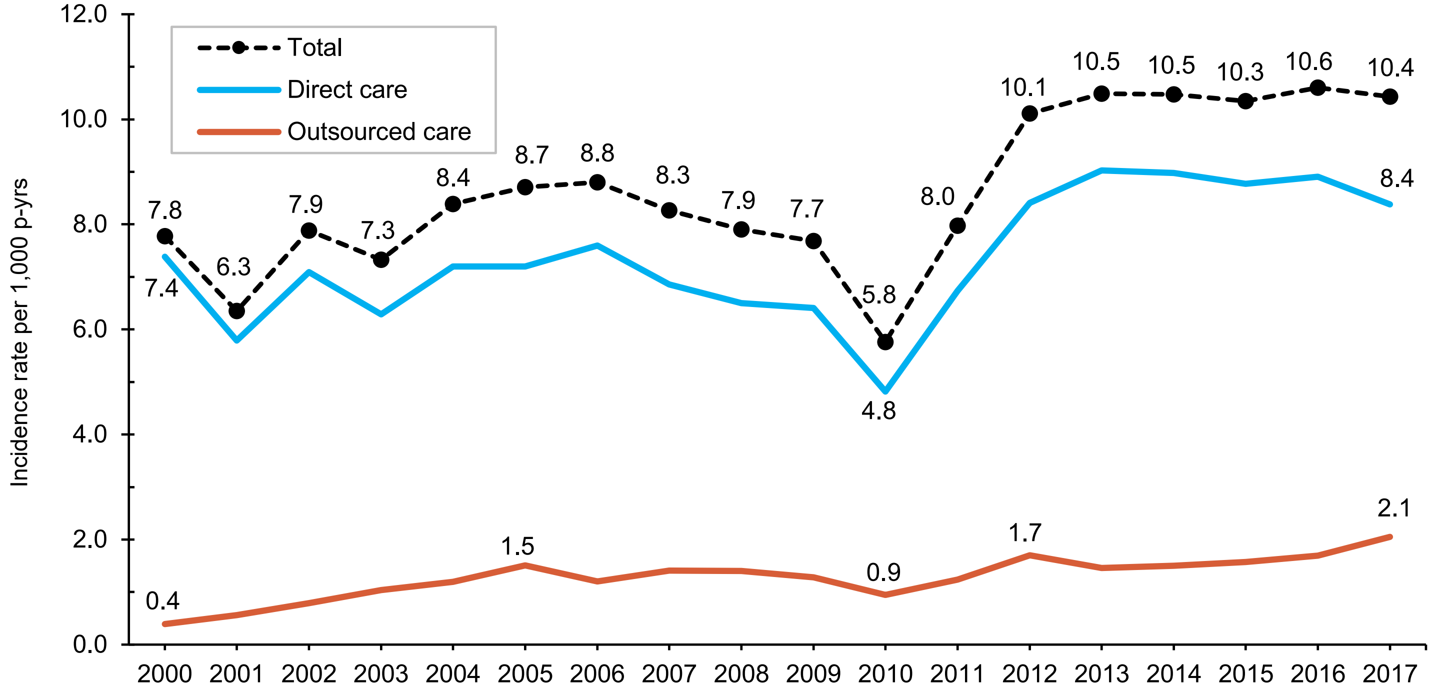
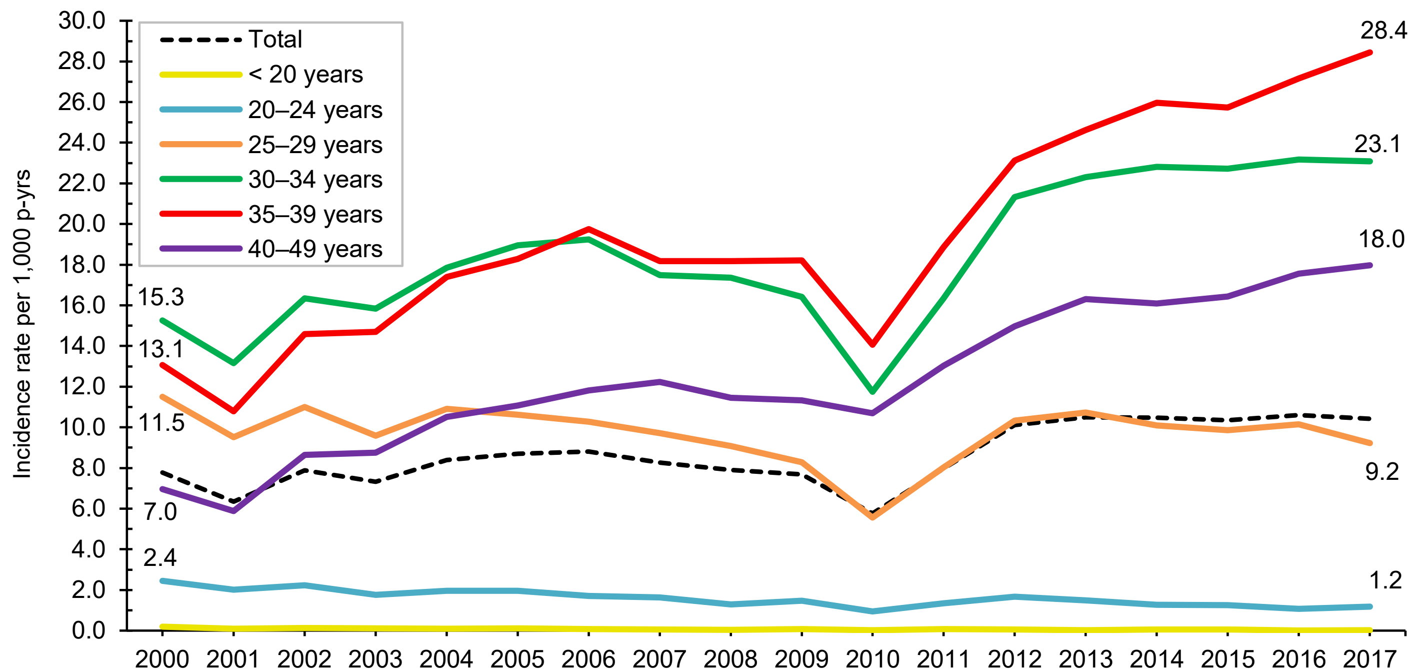


FIGURE 2. Incidence rates of surgical vasectomy, by age group, active component, U.S. Armed Forces, 2000–2017



years, 1.7% aged 30–34 years, 0.7% aged 35–39 years, and 0.4% aged 40–49 years. None of the service men who were 50 years of age or older at the time of vasectomy had documentation of a vasectomy reversal during the surveillance period. Non-Hispanic black (2.3%) and Hispanic (2.3%) service men were more likely than those of other/unknown race/ethnicity (2.0%), non-Hispanic whites (1.7%), or Asian/Pacific Islanders (1.5%) to receive vasectomy reversals. In addition, vasectomy reversals were more likely to be performed among service men who had undergone vasectomy while single, never

FIGURE 3. Incidence rates of surgical vasectomy, by race/ethnicity group, active component, U.S. Armed Forces, 2000–2017

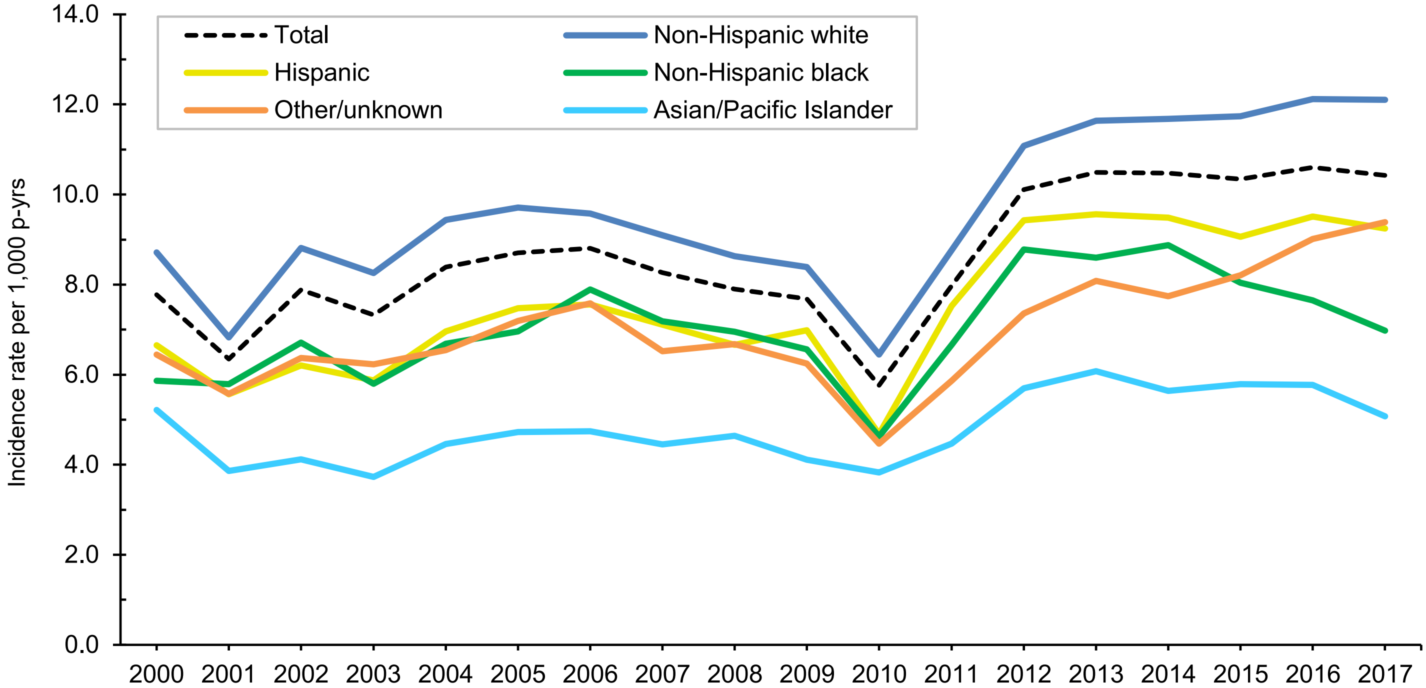
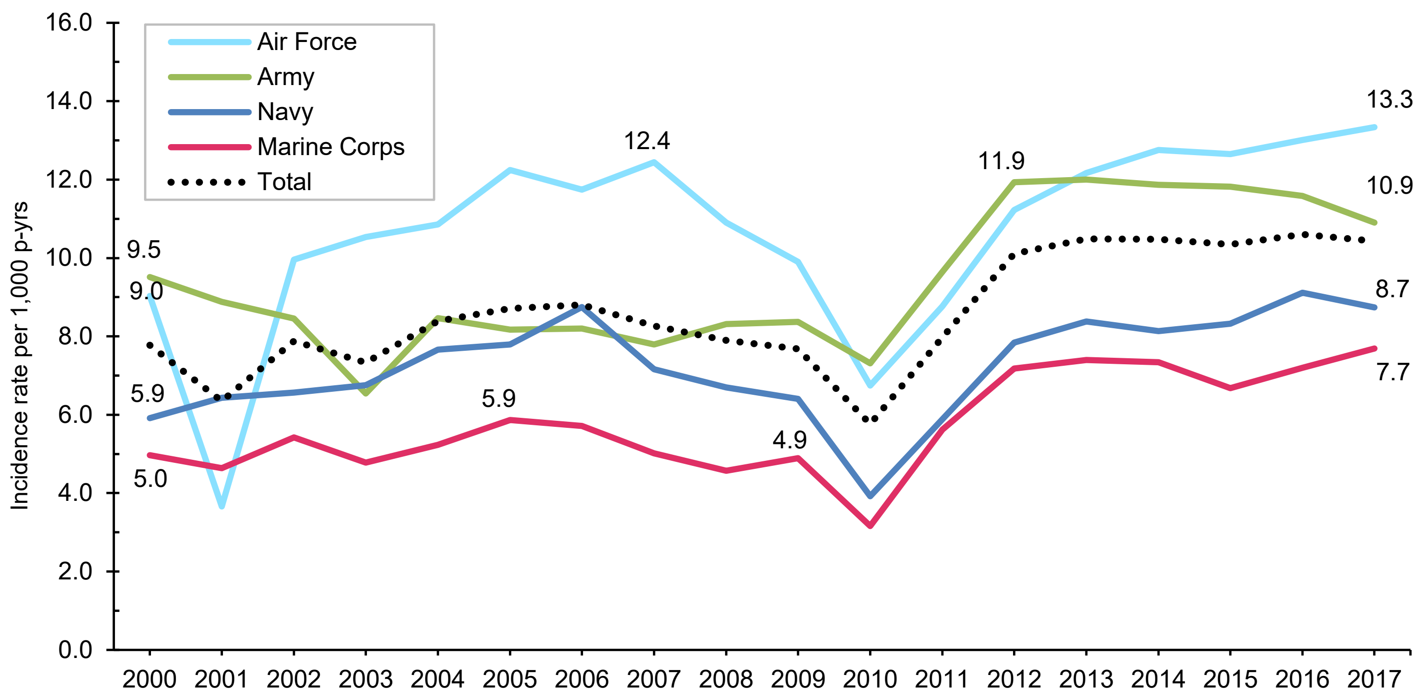


FIGURE 4. Incidence rates of surgical vasectomy, by service, active component, U.S. Armed Forces, 2000–2017



married (2.6%) or of other/unknown marital status (2.6%) compared with service men who had vasectomies while they were married (1.8%). Among the services, vasectomized men in the Army (2.4%) were more likely to have vasectomy reversals compared with men in the Air Force (1.5%), Navy (1.4%), or Marine Corps (1.3%). Those who had vasectomies performed while they were junior enlisted rank (3.1%) were more likely to later undergo vasectomy reversal than service men in any other rank category, including junior officers (1.8%). Service men who were working as pilots/air crew

TABLE 4. Top 15 installations performing incident vasectomies on active component service men, 2000–2017

Installation	No. incident vasectomies
NMC Portsmouth, VA	7,726
NMC San Diego, CA	5,905
Fort Bragg, NC	5,900
Fort Hood, TX	5,613
Fort Shafter, HI	4,893
Fort Carson, CO	4,854
Joint Base Lewis-McChord, WA	4,638
NMC Camp Lejeune, NC	3,950
Fort Campbell, KY	3,939
Camp Pendleton, CA	3,301
Landstuhl RMC, Germany	3,271
Fort Stewart, GA	3,248
NH Jacksonville, FL	2,537
Fort Bliss, TX	2,479
Fort Belvior, VA	2,451

NMC, Naval Medical Center; RMC, Regional Medical Center; NH, Naval Hospital

at the time of vasectomy (0.9%) were less likely to undergo vasectomy reversal than vasectomized service men in any other occupational category.

EDITORIAL COMMENT

The results of the current study show that the crude annual incidence rates of vasectomy among active component service members increased slightly between 2000 and 2017. Data on trends in incidence of vasectomy in the general U.S. population during a comparable time period were not available at the time of this report, precluding comparisons to the current results. U.S. studies using claims data have shown that the prevalence of vasectomies decreased from 2007 through 2015 among men with employer-based insurance in all age groups.[5,6] However, the generalizability of these claims-based findings is limited by the lack of inclusion of self-insured, Medicaid, or uninsured patients.[5,6]

The crude overall vasectomy incidence rate of 8.6 per 1,000 p-yrs observed in the current study is very similar to the age-adjusted rate of 8.7 per 1,000 service men reported by Santomauro et al. in their study of active duty service men but slightly lower than that for the U.S. general population (10 per 1,000 men aged 25–49).[7,16] As noted by Santomauro and colleagues, this finding suggests that U.S. active component service men's access to no-cost care through the MHS is not associated with more vasectomies than in the general population.[16] There are no formal U.S. Department of Defense policies regarding vasectomies for active component service members. However, there are clinically recognized standards for consideration of a sterilization procedure for a service man, including age, number of children, and reasons for desiring the procedure. While the determination of whether a patient is a good candidate for vasectomy is dependent on the critical judgement of the provider performing the procedure, the decision to pursue vasectomy is generally the product of joint decision making.

TABLE 5. Demographic and military characteristics[a] of service men who had an incident vasectomy and at least 1 vasectomy reversal, active component, U.S. Armed Forces, 2000–2017

	Total 2000–2017	
	No.	% of Incident vasectomy cases
Total	3,134	1.8
Setting		
Inpatient	11	4.0
Outpatient	3,123	1.8
Care type for vasectomy		
Direct care	2,807	1.9
Outsourced care	327	1.3
Age group (years)		
<20	10	4.7
20–24	431	5.0
25–29	1,380	3.1
30–34	931	1.7
35–39	308	0.7
40–49	74	0.4
50+	0	0.0
Race/ethnicity		
Non-Hispanic white	2,007	1.7
Non-Hispanic black	494	2.3
Hispanic	404	2.3
Asian/Pacific Islander	54	1.5
Other/unknown	175	2.0
Marital status		
Single, never married	106	2.6
Married	2,908	1.8
Other/unknown	120	2.6
Service		
Army	1,681	2.4
Navy	491	1.4
Air Force	738	1.5
Marine Corps	224	1.3
Rank		
Junior enlisted (E1–E4)	644	3.1
Senior enlisted (E5–E9)	2,000	1.9
Junior officer (O1–O3; W1-W3)	386	1.8
Senior officer (O4–O10; W4-W5)	104	0.5
Military occupation		
Combat-specific[b]	487	2.0
Motor transport	90	2.2
Pilot/air crew	103	0.9
Repair/engineering	1,006	1.9
Communications/intelligence	679	1.9
Healthcare	351	2.4
Other/unknown	418	1.6

[a]At the time of the incident vasectomy
[b]Infantry/artillery/combat engineering/armor

In the current study, the crude overall incidence of vasectomy was highest among service men aged 30–39 years, non-Hispanic white service men, and those who were married at the time of vasectomy. These demographic subgroup-specific findings mirror the results of vasectomy studies in the general U.S. population.[2,4,18,19] Multiple studies have described the association between race and vasectomy utilization, with non-Hispanic white men being more likely to use vasectomy as a means of permanent contraception compared to men in other race/ethnicity groups.[2,7,20,21] Santomauro et al.'s study of active duty service men also reported a higher vasectomy rate among non-Hispanic whites compared to non-Hispanic blacks; data on other race/ethnicity groups were not available for analysis.[16] In the current study, Asian/Pacific Islander service men had the lowest overall vasectomy incidence rate. At the time of this report, only 1 U.S. study reported finding that Asians had the lowest rate of vasectomy relative to other race/ethnicity groups.[20]

The reasons underlying differences in vasectomy rates by race/ethnicity are likely multifactorial. Possible explanations include cultural differences in factors such as preferences for children, union stability, and differential contact with the healthcare system.[7,21,22] However, even among continuously married couples, non-white/minority men are far less likely to undergo vasectomy than their white counterparts.[22] The current finding that married status is positively associated with vasectomy occurrence is consistent with the results of several U.S. studies.[2,18,23]

The median age at incident vasectomy in the current study was 32 years. This finding is consistent with results from Santomauro et al. who reported a mean age at vasectomy of 32.6 years among active duty service men.[16] In addition, the median age at vasectomy in the current study falls within the range of median and mean ages reported in the published literature from NSFG studies.[2,4,18] U.S. administrative data-based studies report a median age at vasectomy of 38 years among employer-insured men.[5,6] In the current analysis, Hispanic service men had the youngest median age at vasectomy and Asian/Pacific Islander service men had the oldest median age at vasectomy. In the U.S., it has been noted that Asian men have an older mean paternal age compared with the mean paternal ages of non-Hispanic whites and non-Hispanic blacks.[24] This older paternal age among Asian men in the general U.S. population may explain, at least in part, the older age at vasectomy observed among Asian/Pacific Islander service men in the current study.

Results of the current analysis also showed that while more than four-fifths of incident vasectomies took place in MTFs during 2000–2017, the annual rate of incident vasectomy performed in non-military facilities increased more than 5-fold from the beginning to the end of the surveillance period.

The rate of repeat vasectomy observed in the current study was 2.2%. In the U.S., the risk of vasectomy failure requiring repeat vasectomy has been noted to be less than 1% provided that a technique for vas occlusion known to have a low occlusive failure rate was used.[1,7,25,26] However, estimates of the rates of repeated vasectomy in the U.S. are derived from studies of vasectomy failure as measured by the number and timing of tests and the end points accepted and not from administrative data on the number of actual procedures performed.[10] No U.S. estimates of the number of repeated vasectomy procedures were available at the time of this report.

During 2000–2017, 1.8% of the service men who had vasectomies also underwent vasectomy reversal during the surveillance period. This rate is lower than the approximately 6% vasectomy reversal rate reported for the general U.S. population.[11–13] Vasectomy reversals are offered in the MHS but require general anesthesia and reserved time in the operating room. Vasectomy reversal is available to active component service members. However, TRICARE, the civilian care component of the MHS, does not cover the cost of vasectomy reversal unless medically necessary.[27]

The results of the current analysis corroborate findings of earlier studies, which showed that younger men were more likely to seek vasectomy reversal.[12,17,28] Several potential reasons for this association have been posited, including a higher likelihood of divorce and remarriage (especially to a nulliparous partner), an altered attitude toward family size, and an improved financial situation as these younger men age.[12,17,28–31] The current finding that vasectomy reversals were more likely to be performed among service men who underwent vasectomy while single may suggest that a change in marital status occurred after vasectomy.

In the current analysis, non-Hispanic black and Hispanic service men were more likely than those of other race/ethnicity groups to undergo vasectomy reversals; Asian/Pacific Islander service men were the least likely to have vasectomy reversals. In their study of active duty service men, Masterson et al. also reported that Asian service men were less likely than non-Hispanic white service men to undergo vasectomy reversal; Hispanics were not represented in their study because they were not identified in the data source.[17]

Results of the current study should be interpreted in the context of several important limitations. First, as incident vasectomies were identified based on the presence of a qualifying ICD-9 or ICD-10 inpatient procedural code or a qualifying outpatient CPT code recorded during a healthcare encounter, the validity of the results depends upon the accuracy of the physician-assigned procedural coding generated by a given encounter. In addition, it is possible that some of the vasectomies identified in the current analysis were performed for medical or therapeutic reasons (e.g., groin pain) and not for sterilization. Laparoscopic vasectomies were not included in the current analysis because there is no specific CPT code for this procedure. However, because this is the least commonly performed vas procedure, the number of missed cases is likely small.[9] As with vasectomies, it is possible that some of the vasectomy reversals included in the current analysis were not carried out to restore fertility. While the vast majority of vasovasostomies are performed to reverse a prior vasectomy, the procedure is occasionally indicated for the repair of vas injury secondary to prior surgery or trauma.[14] Finally, given the varying lengths of follow-up due to service members' departure from active service or the end of the study period, there were likely additional vasectomy reversals that were not captured in these data.

Another limitation of the current analysis is related to the implementation of MHS GENESIS, the new electronic health record for the MHS. For 2017, medical data from sites that were using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at 1 of these facilities during 2017 were not included in the analysis.

As 1 of the few published studies of vasectomy and vasectomy reversal incidence among a large demographically diverse population of U.S. active component service men, this study makes a useful contribution to the literature on temporal changes in the incidence of these surgical procedures by age and race/ethnicity. Observed differences in incidence rates of vasectomy by service and military occupation warrant further analysis to examine adjusted (e.g., by age, race/ethnicity, and marital status) incidence rates among service members within these groups. In addition, further analysis of the sociodemographic characteristics of service men who underwent vasectomy and subsequent vasectomy reversal may help delineate factors impacting sterilization, which may help inform future pre-vasectomy counseling and thus patient choice.

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Brief Report: Male Infertility, Active Component, U.S. Armed Forces, 2013–2017

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Infertility, defined as the inability to achieve a successful pregnancy after 1 year or more of unprotected sexual intercourse or therapeutic donor insemination, affects approximately 15% of all couples.[1–3] Male infertility is diagnosed when, after testing both partners, reproductive problems have been found in the male.[1] A male factor contributes in part or whole to about 50% of cases of infertility.[4–6] However, determining the true prevalence of male infertility remains elusive, as most estimates are derived from couples seeking assistive reproductive technology in tertiary care or referral centers, population-based surveys, or high-risk occupational cohorts, all of which are likely to underestimate the prevalence of the condition in the general U.S. population.[2,7–12]

Infertility in men is typically evaluated using semen analysis to assess sperm concentration, motility, and morphology. The most common causes of male infertility are low sperm production, abnormal sperm function, or problems that affect sperm transport.[10] However, the cause of male infertility is unknown (idiopathic male infertility) in up to 40% of cases,[7,10] and while many infertile men have oligospermia (low sperm concentrations compared with reference ranges) or azoospermia (the absence of motile sperm in semen), some infertile men have normal sperm concentrations.[7] Illness, infection, injury, chronic medical conditions, hormonal disorders, genetic disorders, and lifestyle choices (e.g., heavy alcohol use, smoking, or illicit drug use) also may contribute to male infertility.[13] In addition, frequent exposure to certain environmental elements such as high temperatures, toxins, medications, and radiation can adversely affect sperm production and/or sperm function.[13]

The current report updates and expands on the findings of the previous *MSMR* analysis of infertility among active component service men.[14] Specifically, the current report summarizes the frequencies, rates, temporal trends, types of infertility, and demographic and military characteristics of infertility among active component service men during 2013–2017.

METHODS

The surveillance period was 1 January 2013 through 31 December 2017. The surveillance population consisted of active component service members of the U.S. Army, Navy, Air Force, or Marine Corps who served at any time during the surveillance period. Diagnoses were ascertained from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System (MHS) or civilian facilities in the purchased care system. These data are maintained in the electronic database of the Defense Medical Surveillance System (DMSS).

For surveillance purposes, an incident case of male infertility was defined by a case-defining diagnosis **(Table 1)** in the first diagnostic position of a record of an inpatient or outpatient medical encounter.[15] These cases were then grouped into 5 types of male infertility based on the ICD coding system: male infertility unspecified, azoospermia, oligospermia, other male infertility, and infertility due to extratesticular causes. Infertility due to extratesticular causes (ICD-9) was considered a type of male infertility during 2013–2015 only. Other male infertility was considered a type during 2015–2017 only.

The incidence date was considered the date of the first hospitalization or outpatient medical encounter that included a case-defining diagnosis of male infertility. An individual could be counted as an incident case of male infertility only once during the surveillance period; service men with a documented diagnosis of infertility prior to the surveillance period were excluded from the analysis. Incidence rates were calculated as incident male infertility diagnoses per 10,000 person-years (p-yrs) and were stratified by infertility type as well as by demographic and military characteristics. To assess the healthcare burden associated with male infertility, medical encounters were analyzed separately. The number of inpatient or outpatient encounters with a case-defining diagnostic code recorded in the primary position and the total number of unique individuals affected were computed for each calendar year in the surveillance period.

RESULTS

During the 5-year surveillance period, a total of 17,542 active component service men received incident diagnoses of male infertility, for a crude overall incidence rate of 32.3 cases per 10,000 p-yrs **(Table 2)**. The majority of incident male infertility cases were unspecified male infertility (71.3%), followed by azoospermia (9.3%), oligospermia (8.2%), other male infertility (6.9%), and infertility due to extratesticular causes (4.2%). Azoospermia (3.0 per 10,000 p-yrs) and oligospermia (2.7 per 10,000 p-yrs) were diagnosed at much lower rates than male infertility, unspecified (23.0 per 10,000 p-yrs).

Compared to their respective counterparts, crude overall rates of incident infertility diagnoses were highest among service men aged 30–34 years (60.1 per 10,000 p-yrs), non-Hispanic blacks (36.5 per 10,000 p-yrs), those who were married (52.1 per 10,000 p-yrs), senior enlisted

TABLE 1. ICD-9 and ICD-10 diagnostic codes used to identify cases of male infertility in electronic health records, active component, U.S. Armed Forces, 2013-2017

ICD-9	ICD-10
606 (male infertility)	N46 (male infertility)
606.0 (azoospermia)	N46.0 (azoospermia)
	N46.01 (organic azoospermia)
	N46.02 (azoospermia due to extratesticular causes)
	N46.021 (azoospermia due to drug therapy)
	N46.022 (azoospermia due to infection)
	N46.023 (azoospermia due to obstruction of efferent ducts)
	N46.024 (azoospermia due to radiation)
	N46.025 (azoospermia due to systemic disease)
	N46.029 (azoospermia due to other extratesticular causes)
606.8 (infertility due to extratesticular causes)	
606.1 (oligospermia)	N46.1 (oligospermia)
	N46.11 (organic oligospermia)
	N46.12 (oligospermia due to extratesticular causes)
	N46.121 (oligospermia due to drug therapy)
	N46.122 (oligospermia due to infection)
	N46.123 (oligospermia due to obstruction of efferent ducts)
	N46.124 (oligospermia due to radiation)
	N46.125 (oligospermia due to systemic disease)
	N46.129 (oligospermia due to other extratesticular causes)
606.9 (male infertility, unspecified)	N46.8 (other male infertility)
	N46.9 (male infertility, unspecified)

service men (45.1 per 10,000 p-yrs), those working as pilots/air crew (40.9 per 10,000 p-yrs), and those who had 2 or more prior deployments (44.4 per 10,000 p-yrs). Across the services, overall rates of male infertility diagnoses were highest among Army (38.8 per 10,000 p-yrs) or Air Force members (36.6 per 10,000 p-yrs) and lowest among Marine Corps members (20.2 per 10,000 p-yrs) **(Table 2)**.

Annual rates of incident diagnoses of total male infertility decreased slightly from 35.2 per 10,000 p-yrs in 2013 to 30.3 per 10,000 p-yrs in 2017 **(Figure 1)**. Rates of diagnoses of male infertility, unspecified showed a steady decrease (35.7%) over the course of the 5-year period from 28.0 per 10,000 p-yrs in 2013 to 18.0 per 10,000 p-yrs in 2017. Annual rates of incident azoospermia diagnoses increased from 2.2 per 10,000 p-yrs in 2013 to 4.3 per 10,000 p-yrs in 2017, while annual rates of incident oligospermia diagnoses were relatively stable during the period. Annual incidence rates of other male infertility diagnoses (ICD-10 only) increased markedly, rising from 1.2 per 10,000 p-yrs in 2015 (first year of use of this diagnostic code) to 5.3 per 10,000 p-yrs in 2017. Annual rates of infertility due to extratesticular causes (ICD-9 only) remained relatively low and stable during 2013–2015 **(Figure 1)**.

Stratification of annual incidence rates of male infertility diagnoses by age group showed that rates among service men aged 30–34 years were consistently higher than rates among those in other age groups **(data not shown)**. During the 5-year surveillance period, annual rates of incident diagnoses of male infertility decreased in each service **(Figure 2)**. During each year of the period, incidence rates of male infertility diagnoses were highest among Army and Air Force members. Annual rates of male infertility diagnoses were intermediate among Navy members and lowest among Marine Corps members. However, compared to their respective counterparts, service men in the Army showed the greatest decrease (16.3%) in male infertility rates over time. Decreases over time in annual rates of incident male infertility diagnoses were seen in all race/ethnicity groups; Hispanic service men showed the greatest decrease over time and those of other/unknown race/ethnicity and non-Hispanic black service men showed the smallest decreases **(Figure 3)**.

From 2013 through 2017, annual numbers of medical encounters during which male infertility was recorded as a primary (first-listed) diagnosis decreased 21.8% between 2013 and 2017 **(Figure 4)**. Because there was a comparable decrease (21.4%) in the number of individuals affected, the ratio of medical encounters per individual affected remained steady at 1.6 throughout the surveillance period.

EDITORIAL COMMENT

Annual rates of incident diagnoses of total male infertility among active component service men decreased slightly during 2013–2017. The overall trend in annual rates closely reflected and was primarily influenced by the trend in incident diagnoses of unspecified male infertility. Data on trends in the incidence of male infertility in the general U.S. population during a comparable time period were not available at the time of this report, precluding comparisons to the current results.

Similar to the findings of the 2014 *MSMR* analysis of incident diagnoses of male infertility among active component service men during 2000–2012, annual rates were consistently higher among service men aged 30–34 years compared to those in other age groups.[14] The overall rate of incident diagnoses of male infertility was also highest among non-Hispanic black service men, which is consistent with the findings of the prior *MSMR* analysis.[14] U.S. data on male factor infertility by race/ethnicity are limited in the current

TABLE 2. Incidence counts and rates[a] of male infertility, active component, U.S. Armed Forces, 2013–2017

	Total 2013–2017 No.	Rate
Total	17,542	32.3
Infertility type		
Azoospermia (ICD-9: 606.0; ICD-10: N46.0*)	1,631	3.0
Oligospermia (ICD-9: 606.1; ICD-10: N46.1*)	1,447	2.7
Other male infertility (ICD-10: N46.8)[b]	1,210	2.2
Infertility due to extratesticular causes (ICD-9: 606.8)[c]	744	1.4
Male infertility, unspecified (ICD-9: 606.9; ICD-10: N46.9)	12,510	23.0
Race/ethnicity		
Non-Hispanic white	10,898	32.9
Non-Hispanic black	2,845	36.5
Hispanic	2,207	29.4
Asian/Pacific Islander	516	24.9
Other/Unknown	1,076	28.5
Age group (years)		
<20	33	0.7
20–24	2,573	14.4
25–29	5,396	42.9
30–34	5,043	60.1
35–39	3,013	52.3
40–44	1,157	35.4
45+	327	18.1
Marital status		
Single, never married	1,092	4.9
Married	15,625	52.1
Other/unknown	825	43.3
Service		
Army	7,978	38.8
Navy	3,305	25.8
Air Force	4,542	36.6
Marine Corps	1,717	20.2
Rank		
Junior enlisted (E1–E4)	4,447	18.6
Senior enlisted (E5–E9)	9,541	45.1
Warrant officer (W01–W05)	346	42.8
Junior officer (O1–O3)	2,070	40.8
Senior officer (O4–O10)	1,138	33.7
Military occupation		
Combat-specific[d]	2,638	29.4
Motor transport	497	32.0
Pilot/air crew	924	40.9
Repair/engineering	5,534	32.7
Communications/intelligence	3,638	34.1
Healthcare	1,374	36.1
Other/unknown	2,937	29.0
Number of prior deployments		
0	4,902	20.3
1	4,071	37.3
2+	8,569	44.4

[a]Rate per 10,000 person-years
[b]Measured 2015–2017
[c]Measured 2013–2015
[d]Infantry/artillery/combat engineering/armor
*Any digit/character

FIGURE 1. Annual rates of incident male infertility diagnoses, by infertility type, active component, U.S. Armed Forces, 2013–2017

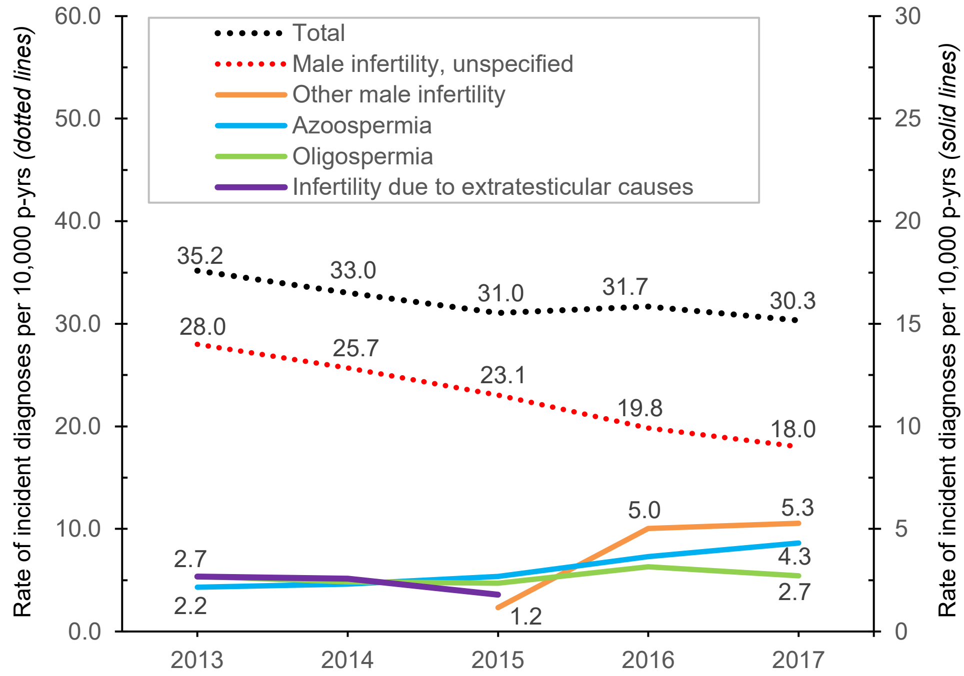
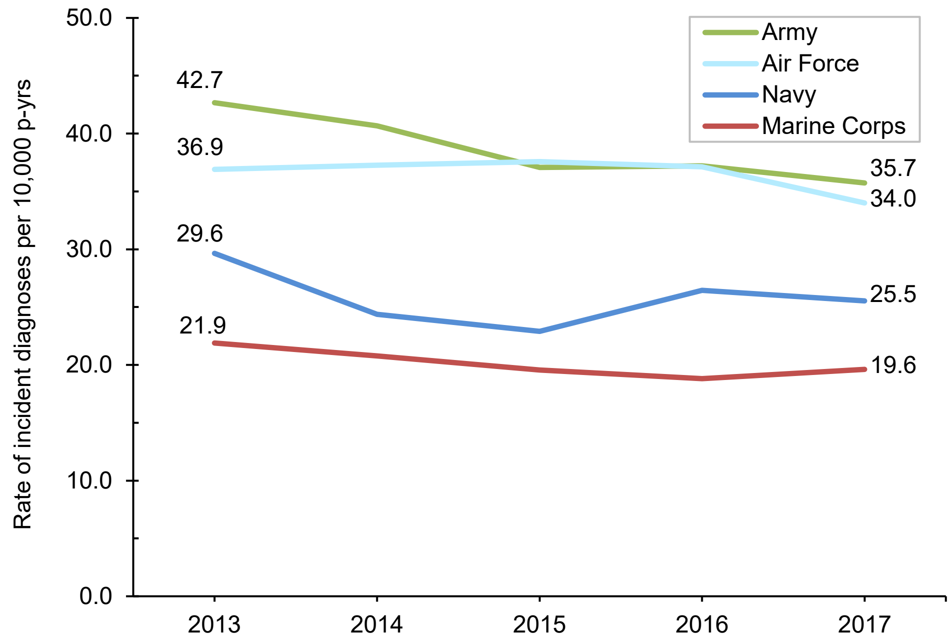


FIGURE 2. Annual rates of incident male infertility diagnoses, by service, active component, U.S. Armed Forces, 2013–2017



literature. In age-adjusted analyses of data from U.S. veterans, Hispanic men had the highest frequency of treatment for male infertility, followed by non-Hispanic black men and non-Hispanic white men.[16] However, a 2001 retrospective study using a centralized database of patient records at a single military male infertility clinic found that race did not appear to be a significant factor influencing the prevalence of male infertility (i.e., the racial background of the study population mirrored that of all MHS

FIGURE 3. Annual rates of incident male infertility diagnoses, by race/ethnicity group, active component, U.S. Armed Forces, 2013–2017

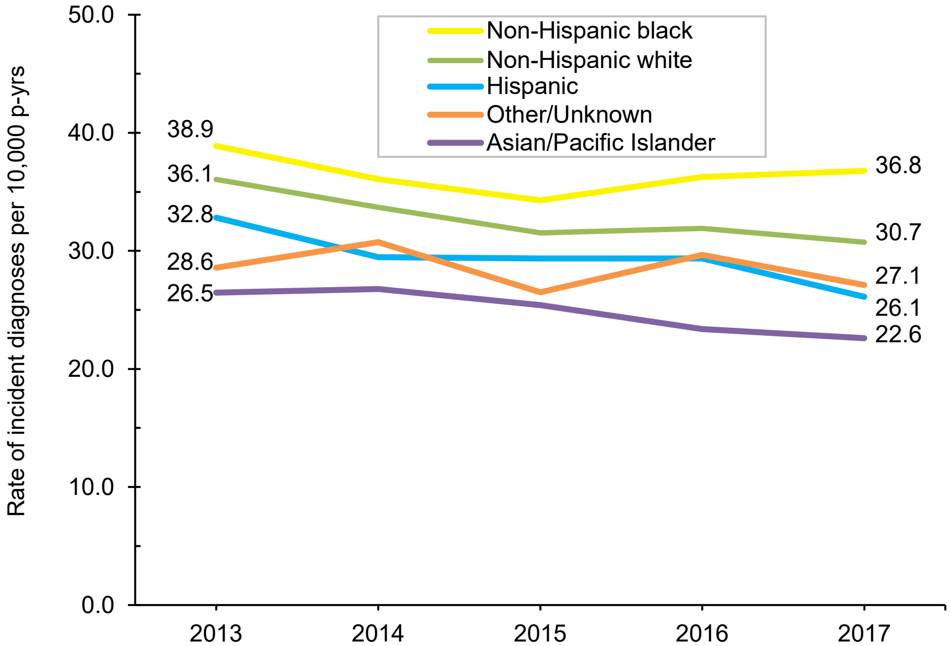
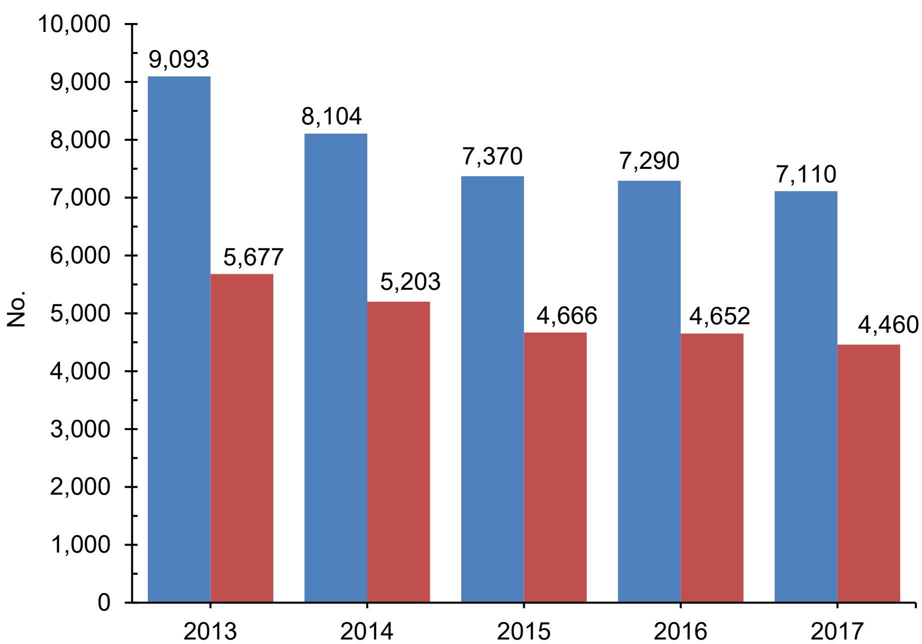


FIGURE 4. Numbers of medical encounters[a] for male infertility and individuals affected[b], active component, U.S. Armed Forces, 2013–2017



[a]Total inpatient and outpatient visits for male infertility in primary diagnostic position (with no more than 1 encounter per individual per day).
[b]Total unique individuals with at least 1 medical encounter for the condition.
Note: The total number of medical encounters included 28 hospital bed days; the remainder of the encounters were ambulatory visits.

beneficiaries).[17] More recently, in samples of U.S. men seeking infertility evaluation and/or treatment, non-Hispanic blacks were found to have lower mean semen volume, sperm concentration, total sperm count, and total motile sperm than non-Hispanic whites or Hispanics.[18–21]

In the current analysis, azoospermia accounted for 9.3% of the incident diagnoses of infertility. This finding is similar to prior literature, which found that 10–15% of all infertile men produce semen devoid of viable sperm.[22–24]

The results presented here must be interpreted in light of several important limitations. First, to the extent that some affected service men did not seek care for infertility or sought care outside of the MHS, the counts and rates reported here underestimate the actual counts and rates of male infertility in the active component of the U.S. Armed Forces. Another limitation of the current analysis is related to the implementation of MHS GENESIS, the new electronic health record for the MHS. For 2017, medical data from sites that were using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at any of these facilities during 2017 were not included in the analysis. Finally, because incident cases were identified based on the presence of a qualifying ICD-9 or ICD-10 diagnosis code for male infertility recorded during a healthcare encounter, the validity of the results depends upon the accuracy of a physician-assigned diagnosis of male infertility and the resultant diagnostic coding generated by a given encounter. However, a recent claims-based study of 11,068 male patients at a single U.S. institution to assess whether ICD-9 codes accurately identified men with abnormal semen analyses[25] found that the specificity of diagnostic coding for azoospermia, oligospermia, infertility due to extratesticular causes, and unspecified male infertility were all greater than 90%. However, sensitivity was not calculated, as not all patients had a documented semen analysis.[26]

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Testosterone Replacement Therapy Use Among Active Component Service Men, 2017

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This analysis summarizes the prevalence of testosterone replacement therapy (TRT) during 2017 among active component service men by demographic and military characteristics. This analysis also determines the percentage of those receiving TRT in 2017 who had an indication for receiving TRT using the 2018 American Urological Association (AUA) clinical practice guidelines. In 2017, 5,093 of 1,076,633 active component service men filled a prescription for TRT, for a period prevalence of 4.7 per 1,000 male service members. After adjustment for covariates, the prevalence of TRT use remained highest among Army members, senior enlisted members, warrant officers, non-Hispanic whites, American Indians/Alaska Natives, those in combat arms occupations, healthcare workers, those who were married, and those with other/unknown marital status. Among active component male service members who received TRT in 2017, only 44.5% met the 2018 AUA clinical practice guidelines for receiving TRT.

WHAT ARE THE NEW FINDINGS?

In 2017, the prevalence of TRT use among active component service men was 4.7 per 1,000. Using the 2018 AUA clinical practice guidelines, only 44.5% of those receiving TRT had an indication to be on the medication.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Out of every 1,000 male service members, almost 3 are inappropriately receiving TRT. Those being inappropriately treated may experience adverse effects of the medication, including obstructive sleep apnea, worsening of urinary tract symptoms, and edema. These adverse effects have the potential to impact deployability and medical readiness.

Testosterone deficiency, also known as hypogonadism or testicular hypofunction, is a combined biochemical and clinical syndrome in adult males characterized by low levels of circulating total testosterone that may adversely affect multiple organ systems and quality of life.[1] In healthy men aged 18–50 years, total serum testosterone levels range from 300 ng/dl to 1000 ng/dl.[2] These levels start to fall significantly after 50 years of age.[2] The Baltimore Longitudinal Study of Aging found that 12% of men in their 50s and 50% of men in their 80s had total serum testosterone levels below 325 ng/dl.[3] The average drop in testosterone is estimated at 3 ng/dl per year for men in their 50s and 11 ng/dl per year for men in their 80s.[1] When hypogonadism is defined as a total serum testosterone level less than 300 ng/dl combined with symptomatic clinical criteria, the estimated prevalence of testosterone deficiency in the U.S. ranges from 5.6% to 6.5%.[4]

The American Urological Association (AUA) 2018 guidelines for the evaluation and management of testosterone deficiency recommend that clinicians use a total serum testosterone level below 300 ng/dl as a reasonable cutoff in support of the diagnosis of low testosterone.[5] An additional recommendation was that the laboratory diagnosis of low testosterone should be made only after 2 total testosterone level measurements below 300 ng/dl on serum specimens taken on separate occasions.[5] Finally, the AUA recommendation for a clinical diagnosis of testosterone deficiency is at least 1 total testosterone level below 300 ng/dl in addition to appropriate physical, cognitive, and/or sexual signs and symptoms.[5,6] These clinical signs and symptoms include fatigue, reduced energy, reduced endurance, diminished physical performance, loss of body hair, reduced lean muscle mass, obesity, depressive symptoms, cognitive dysfunction, reduced motivation, poor concentration, poor memory, irritability, reduced sex drive, and reduced erectile function.[2,5]

Testosterone level testing and testosterone replacement therapy (TRT) prescriptions have tripled in recent years, and the estimated prevalence of TRT use among men in the U.S. is 0.9–2.9%.[4,5] However, some men are prescribed TRT without an indication.[5] The AUA estimates that up to 25% of men who eventually receive TRT do not have their testosterone levels checked prior to initiation of therapy. Furthermore, it is estimated that approximately 30% of men who are placed on TRT have no indication for the medication.[5,7] The U.S. Department of Veterans Affairs (VA) also reported a marked increase in the number of veterans who requested TRT for low testosterone levels.[8] As of 2015, more than 85,000 veterans had received TRT through the VA.[9] Many of these veterans insisted that their symptoms were due to "low T," despite having laboratory results indicating normal serum total testosterone levels.[9] In the Military Health System (MHS), there also have been significant increases in the numbers of both TRT and testicular hypofunction diagnoses. From 2007–2011, males aged 25–44 years received androgen prescriptions at rates that increased 30% per year. During this same period, rates of medically coded hypogonadism increased over 40% per year.[10]

There are significant side effects and risks associated with TRT. TRT has been associated with an increased risk of adverse cardiovascular, respiratory, and dermatologic events among older men.[11] There is inconsistent evidence about the effects of TRT in a military age population (17–60 years). Several studies noted adverse effects of TRT in younger populations including topical transference, erythrocytosis, interference with fertility, worsening of severe lower urinary tract symptoms, suppression of spermatogenesis, fluid retention and edema, and obstructive sleep apnea (OSA).[5,6] One recent study noted an increased risk of OSA but no increased risk of cardiovascular or thromboembolic events.[12] With the increasing number of testosterone deficiency diagnoses and potential health risks associated with initiation of TRT, it is important to understand the epidemiology of receipt of TRT by U.S. service men and whether these individuals have an indication for receiving treatment. Previous studies of U.S. service men highlighted the need to connect individual prescriptions with a patient's androgen level in order to evaluate the appropriateness of prescribed TRT.[10]

METHODS

Data were obtained from the Defense Medical Surveillance System (DMSS), which contains records of ambulatory encounters and hospitalizations of active component service members of the U.S. Armed Forces in military and civilian (if reimbursed through the MHS) treatment facilities. The DMSS also contains administrative records for prescriptions dispensed to service members at military treatment facilities (MTFs) or through civilian purchased care. In addition, laboratory data were obtained from the Navy and Marine Corps Public Health Center (NMCPHC), which include data from the Health Level 7 (HL7) database generated within the Composite Health Care System (CHCS) at fixed MTFs. Laboratory testing performed in civilian facilities is not captured in the HL7 database.

The prevalence of TRT utilization during 2017 was defined as the number of service men who had a dispensed prescription in 2017 with a therapeutic class code for androgens (excluding Danazol), among all male active component service members in the Army, Navy, Air Force, or Marine Corps in service during June 2017. Frequency and distribution of the dispensed androgen prescriptions were identified for each service man **(Table 1)**. Covariates included service, age, military rank, race/ethnicity, military occupation, and marital status. Adjusted prevalence estimates were calculated using log binomial regression. All analyses were performed using SAS/STAT® software, version 9.4 (2014, SAS Institute, Cary, NC).

Laboratory tests and medical encounter history were examined for evidence of an indication for TRT among service men with a TRT prescription in 2017. NMCPHC was provided a line listing of service men who received a TRT prescription in 2017. NMCPHC then returned a line listing of those service men with total serum testosterone test results below 300 ng/dl. Total serum testosterone tests conducted prior to the last TRT prescription in 2017 were considered. Laboratory testing data were available for the period from May 2004 through 2017 for Navy service men and July 2006 through 2017 for all other service men. Electronic health records of service men with a TRT prescription in 2017 were also examined for a history of a qualifying diagnosis as indicated by any of the ICD-9 or ICD-10 codes presented in **Table 2**. These codes were identified after review of the relevant literature and current clinical practice guidelines from the Endocrine Society and the AUA.[1,2,5,6] Service men were defined as having a prior indication for TRT if they met the AUA recommendations for 1) laboratory diagnosis (i.e., 2 total testosterone measurements less than 300 ng/dl) and/or 2) clinical diagnosis (i.e., at least 1 total testosterone measurement less than 300 ng/dl and at least 1 qualifying ICD-9 or ICD-10 diagnosis code).[5]

TABLE 1. Frequency and distribution of androgen prescriptions dispensed to 5,093 active component males on TRT in 2017, by drug name

Androgen drug name[a]	No.	%
Total	6,068[b]	100.0
Androderm®	236	3.9
AndroGel®	157	2.6
Aveed®	22	0.4
Axiron®	12	0.2
Depo-testosterone	2,106	34.7
Fortesta	2,150	35.4
Natesto®	7	0.1
Oxandrolone	8	0.1
Striant®	7	0.1
Testim®	51	0.8
Testopel®	39	0.6
Testosterone	234	3.9
Testosterone cypionate	968	16.0
Testosterone enanthate	69	1.1
Testred	2	0.0

[a]Excluding Danazol
[b]Exceeds number of service men who received TRT (5,093) as some received multiple medications

RESULTS

During the 1-year surveillance period, a total of 5,093 active component service men had a filled prescription for TRT, yielding a crude period prevalence of 4.7 per 1,000 male service members **(Table 3)**. Army service men had a higher prevalence of TRT use compared to men in the other service branches (6.3 per 1,000). Warrant officers (14.5 per 1,000) and senior officers (13.1 per 1,000) had a higher prevalence of TRT use compared to enlisted personnel (senior enlisted, 7.7 per 1,000; junior enlisted, 0.5 per 1,000) and junior officers (3.8 per 1,000). In addition, TRT use increased approximately linearly with increasing age as seen in **Table 3**. Non-Hispanic whites and

TABLE 2. ICD-9 and ICD-10 codes for TRT indication

	ICD-9	ICD-10
Definitive diagnosis		
Hypogonadism	257.2	E29.1
Testosterone deficiency	257.2	E29.1
Physical diagnosis		
Fatigue	780.7* (excluding 780.72)	R53* (excluding R53.0 and R53.2)
Infertility, male	606*	N46* (excluding N46.023 and N46.123)
Loss of body hair	704.0*, 704.9	L63*, L64* (excluding L64.0, L64.8 and L64.9), L65*
Decreased muscle mass and strength	729.89	R29.8, R29.89, M62.50,
Decreased bone mineral density	275.4* (excluding 275.42)	E83.5* (excluding E83.52), E83.8* (excluding E83.89), M80, M80.0*, M81.1*, Z87.310
Diabetes mellitus type 2	250.*0, 250.*2	E11*
Metabolic syndrome	277.7	E88.81
Obesity	278, 278.0*, 278.1, V85.3*, V85.4*	E66* (excluding E66.1), Z68.3*, Z68.4*
Pituitary gland disorder	253*	E23*
Testicular dysfunction	257.8, 257.9	E29.8, E29.9
Gynecomastia	611.1	N62
Disorder of puberty	259	E30.0, E30.8, E30.9
Androgen insensitivity syndrome	259.50, 259.51, 259.52	E34.5*
Anosmia	781.1	R43.0
Anemia	280*, 281*	D51*, D52*, D53*, D50*
Sex chromosome abnormality	758.6, 758.7, 758.89	Q98*
Cognitive diagnosis		
Cognitive impairment, mild	331.83	G31.84, F03.9, R41.8, R41.844
Depressed mood	296.2*, 296.3*, 296.82, 296.9*, 300.4	F32*, F33*, F34* (excluding F34.0), R45.2, R45.3
Decreased concentration	799.51	R41.84, R41.840
Irritability	799.22	R45.4
Sexual diagnosis		
Decreased libido	799.81	R68.82
Erectile dysfunction	302.70, 302.71, 302.72, 302.74, 607.84	F52, F52.0, F52.2, F52.21, F52.8, F52.9, N52, N52.1, N52.8, N52.9, N48.9, Z87.43, Z87.438
Testing indicated by history		
HIV+	042 ,V08	B20, Z21
Chronic narcotic use	V58.69	Z79.891
Chronic corticosteroid use	V58.65	Z79.51, Z79.5.2
Postprocedural testicular hypofunction	257.1	E89.5
History of antineoplastic chemotherapy	V87.41	Z92.21

American Indian/Alaska Native service men had the highest prevalence (5.6 per 1,000) compared to service men in other race/ethnicity groups, while non-Hispanic blacks (2.9 per 1,000) and Asian/Pacific Islanders (2.6 per 1,000) had the lowest. Healthcare workers had the highest prevalence (9.8 per 1,000) compared to those in other occupations, while motor transport workers had the lowest (2.2 per 1,000). Finally, service members who were never married had a TRT prevalence of 0.7 per 1,000, while married service men and those with "other/unknown" marital status had a prevalence of 7.5 and 8.1 per 1,000, respectively.

After adjusting for all covariates **(Table 3)**, the prevalence of TRT use remained highest among Army members, senior enlisted members, warrant officers, non-Hispanic whites, American Indian/Alaska Natives, those in combat arms occupations, healthcare workers, those who were married, and those with other/unknown marital status.

Among the 5,093 active component male service members who received TRT in 2017, 25.6% met the laboratory diagnosis criterion of having at least 2 total testosterone measurements that were less than 300 ng/dl. In addition, 44.3% of the service men who received TRT met the clinical diagnosis criteria of having at least 1 total testosterone measurement less than 300 ng/dl and documentation of at least 1 qualifying diagnosis code. Nearly all (99%) of the service men who met the laboratory diagnosis criterion also met the clinical diagnosis criteria. Overall, 44.5% of those who received TRT met the case definition for an indication for TRT **(Table 4)**. Nearly 2 out of every 3 service men in the Navy (65.4%) and service men aged 17–29 years (64.1%) who received TRT did so without an indication for TRT.

EDITORIAL COMMENT

The crude prevalence of TRT of 4.7 per 1,000 service men, or 0.5%, is well below the general U.S population estimate of 0.9–2.9%.[1] This is expected since the U.S. Department of Defense (DoD) active component population is younger on average than the general population, is screened for pre-existing conditions prior to accession into the military, and includes few individuals over 60 years of age. In addition, there is a pronounced gradient of increasing prevalence of TRT use with increasing age. This pattern is consistent with the

TABLE 3. Crude and adjusted prevalence, by demographic and military characteristics, active component males who received TRT in 2017

	No.	Population	Crude prevalence[a]	Adjusted prevalence[a]
Total	5,093	1,076,633	4.7	--
Age group (years)				
17–29	612	701,676	0.9	0.9
30–39	2,153	262,832	8.2	3.9
40–49	1,977	100,585	19.7	9.3
50+	351	11,540	30.4	14.9
Race/ethnicity				
Non-Hispanic white	3,563	641,240	5.6	6.2
Non-Hispanic black	447	156,655	2.9	3.0
Hispanic	646	161,361	4.0	5.3
Asian/Pacific Islander	113	43,658	2.6	2.7
American Indian/Alaska Native	59	10,530	5.6	7.2
Other/unknown	265	63,189	4.2	5.0
Marital status				
Single, never married	308	445,309	0.7	2.7
Married	4,428	587,445	7.5	6.1
Other/unknown	357	43,879	8.1	6.2
Service				
Army	2,489	394,756	6.3	5.7
Navy	1,008	258,325	3.9	4.0
Air Force	1,207	254,667	4.7	5.1
Marine Corps	389	168,885	2.3	4.0
Rank				
Junior enlisted (E1–E4)	240	460,912	0.5	2.2
Senior enlisted (E5–E9)	3,302	426,414	7.7	6.4
Junior officer (O1–O3)	393	102,846	3.8	4.8
Senior officer (O4–O10)	916	69,783	13.1	4.2
Warrant officer (W01–W05)	242	16,678	14.5	7.6
Military occupation				
Combat-specific[b]	1,071	171,965	6.2	7.3
Motor transport	66	30,278	2.2	3.6
Pilot/air crew	142	44,299	3.2	2.2
Repair/engineering	1,302	337,804	3.9	4.6
Communications/intelligence	1,005	203,456	4.9	4.7
Healthcare	725	73,979	9.8	8.3
Other/unknown	782	214,852	3.6	4.5

[a]Per 1,000 service men
[b]Infantry/artillery/combat engineering/armor

published literature on the civilian population and the known biological process of aging.[2]

Before and after adjustment, there were pronounced differences in the prevalence of TRT use between some occupations. The increased prevalence of TRT use among healthcare workers may be related to medical knowledge, access to care, and/or availability of treatment. The higher prevalence observed among those in combat arms occupations could be related to the nature of their work and the associated clinical symptoms. These warfighters are chronically sleep deprived, and that can manifest as depression, fatigue, and irritability.[13] In contrast, pilots and aircrew are anecdotally known for their refusal to seek care, even to the point of concealing illness and injuries, in order to maintain their flight status. Hypogonadism diagnoses result in pilots and aircrew losing their flight status[14]; they then must go through the medical waiver process to regain their certifications.[14] This is a potential explanation for why the prevalence of TRT use in pilots and aircrew is much lower than among service men in other occupational groups. Even after adjustment, there remains an association between TRT and marital status. Compared to single service men, married service men may be more likely to seek care related to difficulties with conceiving a child or because of spousal encouragement to seek care for other comorbid conditions associated with hypogonadism.

Overall, 44.5% of those active component men who received TRT had an indication for receiving treatment when following the 2018 AUA clinical practice guidelines for the management of testosterone deficiency. The finding of 44.5% is substantially less than the AUA's estimation for 70% in the civilian population; however, this could be related to differences in the age distributions of the study populations. The AUA estimation was derived from a 2015 study that used the North Shore University Health System Data Warehouse. However, the average age of the study population was 56 years.[7] In contrast, in the current study, over 90% of the service men on TRT in 2017 were under the age of 50. Older men are more likely to have an indication for TRT because of a higher prevalence of hypogonadism.

This study was limited to active component service men, so comparisons with studies of the civilian population should be regarded with caution given the differences between the 2 populations in terms of age and health status. Furthermore, the data captured in this report may not represent service men's true medical histories, as some members may have been evaluated by non-network civilian providers and possibly paid the costs for this medical care out-of-pocket or through private health insurance. Diagnostic records, laboratory data, and prescription data associated with such non-network health care would not have been included in the current analysis. In addition, subjective signs and symptoms derived from questionnaires have been shown to have poor sensitivity whereas the clinical diagnosis criteria used in the current analysis were based upon a consolidation of definitions of hypogonadism reported in the published literature.[1,2,5,6] Finally, in some general population studies, treatment for hypogonadism was based

TABLE 4. Percent of active component males who received TRT in 2017 who met criteria for laboratory diagnosis, clinicial diagnosis, and indication for TRT (N=5,093)

	Laboratory diagnosis[a]		Clinical diagnosis[b]		Indication for TRT[c]	
	No.	%	No.	%	No.	%
Total	1,306	25.6	2,257	44.3	2,267	44.5
Age						
17–29	118	19.3	217	35.5	220	35.9
30–39	514	23.9	918	42.6	920	42.7
40–49	560	28.3	942	47.6	946	47.9
50+	114	32.5	180	51.3	181	51.6
Race/ethnicity						
Non-Hispanic white	935	26.2	1,599	44.9	1,606	45.1
Non-Hispanic black	100	22.4	179	40.0	179	40.0
Hispanic	174	26.9	295	45.7	298	46.1
Asian/Pacific Islander	29	25.7	47	41.6	47	41.6
American Indian/Alaska Native	10	16.9	24	40.7	24	40.7
Other/unknown	58	21.9	113	42.6	113	42.6
Marital status						
Single, never married	62	20.1	108	35.1	109	35.4
Married	1,152	26.0	1,991	45.0	2,000	45.2
Other/unknown	92	25.8	158	44.3	158	44.3
Service						
Army	647	26.0	1,129	45.4	1,133	45.5
Navy	184	18.3	347	34.4	349	34.6
Air Force	368	30.5	604	50.0	605	50.1
Marine Corps	107	27.5	177	45.5	180	46.3
Rank						
Junior enlisted (E1–E4)	53	22.1	92	38.3	93	38.8
Senior enlisted (E5–E9)	839	25.4	1,454	44.0	1,459	44.2
Junior officer (O1–O3)	74	18.8	144	36.6	146	37.2
Senior officer (O4–O10)	273	29.8	452	49.3	453	49.5
Warrant officer (W01–W05)	67	27.7	115	47.5	116	47.9
Military occupation						
Combat-specific[d]	260	24.3	445	41.5	446	41.6
Motor transport	13	19.7	26	39.4	27	40.9
Pilot/air crew	33	23.2	65	45.8	65	45.8
Repair/engineering	307	23.6	547	42.0	550	42.2
Communications/intelligence	267	26.6	452	45.0	453	45.1
Healthcare	201	27.7	359	49.5	360	49.7
Other/unknown	225	28.8	363	46.4	366	46.8

[a]Two total testosterone measurements less than 300 ng/dl
[b]At least 1 total testosterone measurement less than 300 ng/dl and at least 1 qualifying ICD-9 or ICD-10 code
[c]Either a laboratory or clinical diagnosis
[d]Infantry/artillery/combat engineering/armor

upon other criteria. The 2018 AUA guidelines were released after the surveillance period. Prior to the release of these guidelines, there were no commonly accepted standards for diagnosing hypogonadism.

During 2017, approximately 1 out of every 200 service men (0.47%) was treated with TRT. While this is a smaller percentage than that observed in the civilian population, it still represents a fairly large number of service men. Primary care providers in the MHS should be aware of the prevalence of TRT use in order to properly assess patients presenting with comorbid conditions. Furthermore, those providers who are considering initiating TRT should be aware of the 2018 AUA guidelines in order to reduce the frequency of TRT prescriptions that lack valid indications. The DoD might consider limiting initiation of TRT to those providers with appropriate board certification or other specialized training in order to limit the frequency of inappropriate TRT prescriptions. Such a limitation could lessen the frequency of inappropriate prescriptions of long-term medications by physicians who have not yet completed residency training. Finally, future studies are recommended to examine whether the new clinical practice guidelines are improving the percentage of those receiving TRT who actually have an indication for treatment.

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