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# Epidemiology of Contemporary Seroincident HIV Infection in the Navy and Marine Corps

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**ABSTRACT** Human Immunodeficiency Virus (HIV) infection continues at a steady rate among U.S. Sailors and Marines. This study provides the first service-specific description of HIV infection demographics. All Sailors and Marines identified as HIV infected between January 2005 and August 2010 were included. The project compared personnel and epidemiologic data, and tested reposed sera in the Department of Defense Serum Repository. This group comprised 410 Sailors and 86 Marines, predominantly men. HIV infected Marines were more likely to be foreign born than their Navy counterparts, 42% versus 10%, $p < 0.001$. Approximately half of the patients had deployed including to the wars in Iraq or Afghanistan. Nearly half of each group was infected by the age of 25. Similar to the U.S. epidemic, Black race was over-represented. Unlike national rates, Hispanic Sailors and Marines were not over-represented. Demographics were distinct for those of specific occupational specialties. Certain ship classes carried lower incidences. Clustering of HIV infection risk occurred around deployment. The Navy and Marine Corps have different patterns of HIV infection, which may merit distinct approaches to prevention. The Navy may have unique targets for prevention efforts to include pipeline training and first assignment as well as particular occupational environments.

## BACKGROUND

Human Immunodeficiency Virus (HIV) infection has occurred in the U.S. military since early in the epidemic. Service members identified as HIV infected through compulsory, periodic force-wide screening quickly receive subspecialty, multidisciplinary care and most often are retained in service.[1] Detection of HIV infection and subsequent case management is coordinated through the Navy Bloodborne Infection Management Center (NBIMC). Infected Sailors and Marines are evaluated periodically at designated referral centers and assisted in appropriate duty assignments through the Navy Personnel Command and Headquarters Marine Corps. Mechanisms to ensure case finding and management were constructed to do so while maximizing patient privacy and avoiding stigma. However, these mechanisms have made the routine exploration of disease transmission in the force challenging as systematic compilation of potential exposures has not occurred.

The epidemiology of HIV infection in the Navy and Marine Corps has not been fully described. However, detailed reports of features of infection were published nearly a decade ago with data from a mixed group of Sailors and Marines and more broadly across services from the military's robust HIV natural history study cohort.[2,3] Despite aggressive case finding and treatment as well as force-wide sexual health strategies, Navy and Marine Corps HIV incidence and prevalence have remained stable over the last several years.[4] In 2008, 2009, and 2010, Navy HIV incidence in the active duty component was 0.35, 0.35, and 0.30, respectively per 1,000 persons tested. Incidence in the reserve component was 0.23, 0.22, and 0.42. During this same period, Marine HIV incidence in the active duty component was 0.13, 0.15, and 0.12 per 1,000 persons tested. Reserve component incidence was 0.27, 0.20, and 0.24. Furthermore, effect on HIV infection in the force of repealing restrictions on professed sexual orientation of service members is not known.[5] Optimizing force HIV screening and prevention is a continued challenge in this setting. Early detection may avert transmission through sexual health counseling and treatment.[6] An improved understanding of the contemporary epidemiology of HIV acquisition among the active duty military force may enhance primary prevention efforts.

We sought to characterize contemporary HIV infection in the Navy and Marine Corps. Our objectives were to provide actionable public health intelligence to include informing education and screening practices, identifying transmission networks, assessing program performance and informing practices and providing military medical research entities with sufficient context to continue their work in promoting

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disease prevention. We report the descriptive epidemiology from this effort.

## METHODS

This project identified all enlisted Sailors and Marines with a first known positive HIV screening test between January 1, 2005 and August 3, 2010. Officers comprise a very small fraction of patients and are demographically distinct so this group was not included.

Candidates for entering military service are screened for HIV infection. If found positive, they are not brought into military service. Once in the service, Sailors and Marines are tested every 2 years. Additional testing occurs as clinically indicated or as related to predeployment and postdeployment practices. Force HIV screening and timely clinical testing is performed through a single contract managed by the NBIMC, though in the presence of clinical suspicion some providers also seek local just-in-time testing. From January 2005 through April 2009, screening utilized a second generation enzyme-linked immunosorbent assay (ELISA) confirmed through Western blot. In May 2009, testing shifted to the use of a third generation ELISA confirmed through Western blot. Program managers and clinicians also obtain specialized testing including Nucleic Acid Testing at the HIV Diagnostics and Reference Laboratory at the U.S. Military HIV Research Program (MHRP), Walter Reed Army Institute of Research (WRAIR). This is requested most frequently in the context of acute seroconversion illness.

This project was coordinated by the Bureau of Medicine and Surgery, NBIMC, and the MHRP. It was reviewed by the WRAIR Institutional Review Board and affirmed as a public health activity. The Navy Personnel Command and the Headquarters, U.S. Marine Corps (USMC) provided personnel histories from initial accession into service through the date of first known positive HIV screening test. The provided data elements included place of birth and home of record (HOR), age, gender, marital status, level of education, current rating (Navy), rank (USMC), assignment units and locations, and represented patient status at the time of data pull. The Epidemiology Data Center, Navy Marine Corps Public Health Center provided pre-HIV infection clinical histories and deployment data. Identified linkages were reposed in a secure database within the Data Collection and Analysis Center, MHRP.

The distribution of these demographic variables was described. For Navy race data, 10% of Sailors who self-identified as Other were manually verified through clinical database information populated by the Defense Eligibility Enrollment Reporting System. As Hispanic was a race category for Marines but not Sailors, Hispanic ethnicity of Sailors was tallied regardless of their race selection.[7]

Presumed last negative (LN) serum samples and when necessary earlier samples from the Department of Defense Serum Repository, Armed Forces Health Surveillance Center (Silver Spring, Maryland) were tested to verify the true LN test and true first positive test dates through both third generation ELISA and nucleic acid testing.[8] These revised dates were used to construct risk periods for acquisition of HIV infection and describe potentially relevant exposure risks.

The dates of initial positive (IP) HIV screening test, LN HIV screening test, and previous negative HIV screening test were not corrected when used to report differences in testing intervals among the services. However, IP and LN were corrected to account for false negative serum from the Department of Defense Serum Repository when generating risk windows and calculating the interval between deployment end date and IP HIV test. Risk windows were bound by the dates of true LN and true first positive HIV test results on pulled sera—dates when each patient was known to be HIV uninfected until known to be HIV infected.

Several analyses were incorporated for the purpose of hypothesis generation including exploration of occupational codes, duty assignment, and deployment history.

The degree to which different Sailor occupational specialties (ratings) were represented among NBIMC enrollees were normalized employing a 5-year average of annual force strengths provided by the Navy Personnel Command as denominators. Longitudinal rating data on Sailors was assessed against the first positive HIV test date so that if a Sailor had changed ratings, the rating before known HIV infection was selected. Ratings were coded as this portion of the analysis was exploratory, confounding may be present and undue stigma is a risk.

Sailors' assignments on ships during their risk windows were analyzed in order to generate an incidence of subsequently HIV-infected Sailors by ship class. The Navy Ship List was utilized for number of vessels in service by class as well as standard crew complements.[9] Rate ratios were calculated to compare the rate of HIV incidence by ship class.

Potential associations between deployment and HIV positivity were explored by calculating the intervals between deployment start dates and true first positive and LN HIV test dates. Means for time from deployment start to first positive HIV test were compared using a *t*-test.

Characteristics among Sailors and Marines were compared using the $\chi^2$ test at an $\alpha$ of 0.05. Incidence rates were assessed for significance by constructing 95% confidence interval (CI)s. Data sets were managed and analyzed utilizing Statistical Analysis Software version 9.2 (SAS Cary, North Carolina).

## RESULTS

The analysis group was comprised of 410 Sailors and 86 Marines. In general, Sailors and Marines identified within the study period had IP HIV screening tests within force mandated screening windows following their LN test (83% of Marines' IP tests and 78% of Sailors' were tested within 24 months of their LN test, Table I). More than 50% of both Sailors and Marines had been deployed with 45% and 14%, respectively, having deployed previously to the wars in Iraq and Afghanistan (Operations Iraqi Freedom or Enduring Freedom). Across all deployments, approximately 1 in 5 Sailors and Marines had deployed more than once.

**TABLE I.** Comparative Demographics of HIV Infected Sailors and Marines

| | Service | | | | | |
|---|---|---|---|---|---|---|
| | Marine Corps | | Navy | | Total | |
| | *N* | % | *N* | % | *N* | % |
| Most Recent Rank | | | | | | |
| E1–E4 | 40 | 47 | 171 | 42 | 211 | 43 |
| E5–E9 | 46 | 53 | 239 | 58 | 285 | 57 |
| Gender | | | | | | |
| Female | 2 | 2 | 4 | 1 | 6 | 1 |
| Male | 84 | 98 | 406 | 99 | 490 | 99 |
| Race/Ethnicity* | | | | | | |
| Black | 38 | 44 | 210 | 53 | 248 | 52 |
| White | 29 | 34 | 132 | 34 | 161 | 34 |
| Hispanic | 13 | 15 | | | 13 | 3 |
| Others | 6 | 7 | 51 | 13 | 57 | 12 |
| Missing | 0 | | 17 | 4 | 17 | 3 |
| Current Marital Status* | | | | | | |
| Married | 35 | 41 | 134 | 33 | 169 | 34 |
| Single | 44 | 51 | 59 | 14 | 103 | 21 |
| Other | 7 | 8 | 24 | 6 | 31 | 6 |
| Missing | 0 | 0 | 193 | 47 | 193 | 39 |
| Highest Education Attained | | | | | | |
| High School or Less | 81 | 94 | 373 | 91 | 454 | 92 |
| >High School | 5 | 6 | 37 | 9 | 42 | 8 |
| Region of Birth* | | | | | | |
| Northeast | 12 | 14 | 39 | 10 | 51 | 10 |
| South | 21 | 24 | 213 | 52 | 234 | 47 |
| Midwest | 5 | 6 | 53 | 13 | 58 | 12 |
| West | 2 | 2 | 64 | 16 | 66 | 13 |
| Non-Continental United States, Alaska and Hawaii | 36 | 42 | 41 | 10 | 77 | 16 |
| Missing | 10 | 12 | 0 | 0 | 10 | 2 |
| HOR region* | | | | | | |
| Northeast | 9 | 10 | 34 | 8 | 43 | 9 |
| South | 28 | 33 | 244 | 60 | 272 | 55 |
| Midwest | 3 | 3 | 57 | 14 | 60 | 12 |
| West | 2 | 2 | 69 | 17 | 71 | 14 |
| Non-U.S. | 43 | 50 | 6 | 1 | 49 | 10 |
| Missing | 1 | 1 | 0 | 0 | 1 | 0 |
| Interval, LN to IP, Months* | | | | | | |
| low–12 | 43 | 50 | 165 | 40 | 208 | 42 |
| 13–24 | 28 | 33 | 157 | 38 | 185 | 37 |
| 25–78 | 11 | 13 | 86 | 21 | 97 | 20 |
| >78 | 0 | 0 | 2 | 0 | 2 | 0 |
| Missing | 4 | 5 | 0 | 0 | 4 | 1 |
| No. of Deployments | | | | | | |
| None | 42 | 49 | 195 | 48 | 237 | 48 |
| 1 | 24 | 28 | 131 | 32 | 155 | 31 |
| >1 | 20 | 23 | 84 | 20 | 104 | 21 |
| Deployment Type* | | | | | | |
| Operations Iraqi Freedom or Enduring Freedom | 12 | 14 | 185 | 45 | 197 | 40 |
| Other | 32 | 37 | 30 | 7 | 62 | 13 |

Descriptive epidemiology of HIV-positive service members in the Navy and Marine Corps identified by positive tests between 2005 and 2010. * indicates $p < 0.001$ for comparison of USN and USMC patients. LN, Last Negative; IP, Initial Positive HIV screening test result.

Sailors and Marines were similar in a variety of demographic variables assessed at date of IP serum HIV ELISA (Table I), such as gender and fraction with higher education. Sixteen percent of Sailors self-identified as Hispanic under ethnicity, similar to the number of Marines who identified as Hispanic race. The distribution of length of service (LOS) and age at time of diagnosis also were similar (Fig. 1), though of HIV-infected personnel who were identified when over the age of 25 years, Sailors were older than Marines (more likely to be over 30 years old).

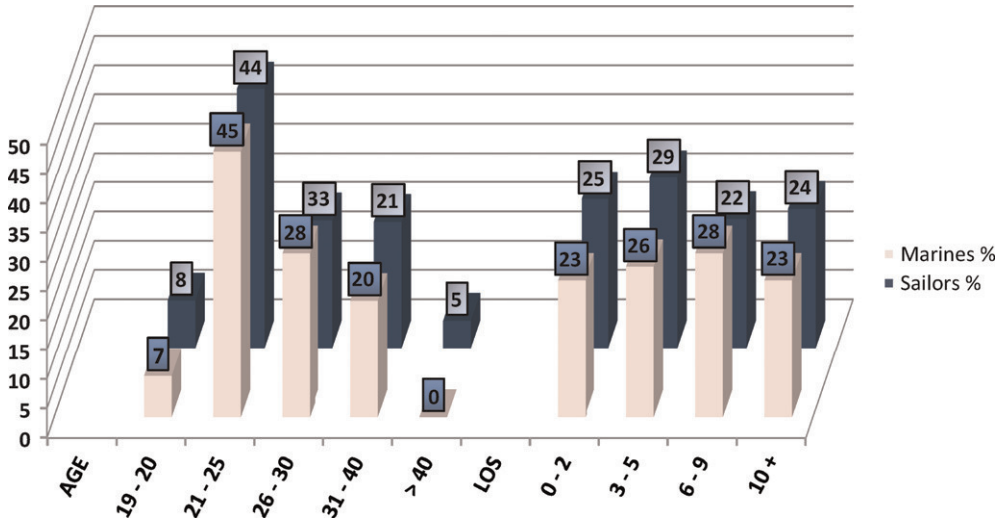


**FIGURE 1.** Distribution of age and length of service (LOS) at time of initial positive test. Marines' values are shown above the corresponding Sailors' values.

HIV-infected Marines were more likely to be born outside of the continental United States, Alaska, and Hawaii than their Navy counterparts representing 42% rather than 10% of those populations. Among Marines, this included 4 individuals from North America, 3 from Europe, 3 from the Caribbean and Central America, 4 from South America, 15 from Asia and the Pacific Islands, and 7 from Africa. Among Sailors, this included 6 individuals from North America, 3 from Europe, 16 from the Caribbean and Central America, 2 from South America, 14 from Asia and the Pacific Islands. Within the United States, Sailors had twice the rate of being born in the southern states than Marines.

HIV-infected Marines were widely distributed across Marine Occupation Specialties (not shown). However, some Sailor occupational ratings demonstrated increased rates of HIV infection in the study period (Table II).

Rating F was the most prevalent rating among incident HIV infections. The demographics of HIV-infected Sailors in rating F differed in several ways from the remainder of infected Sailors, and from rating B, the second most prevalent rating. HIV-infected Sailors in rating F were more likely to be a mixed group of self-reported White (39%) and Black (38%) with fairly well distributed regions of birth and homes of record. Those in rating B, the second most prevalent, more commonly self-reported as Black (76%) from the South (82%). Overall, Sailors in rating F were less likely to have deployment experience, but more likely to have deployment experience in Iraq or Afghanistan—18% for rating F, 12% for rating B, 4% for all other ratings. In rating B, 2 in 5 Sailors were identified within 2 years of service in contrast to 1 in 4 of those in other ratings.

HIV-infected Sailors and Marines were well distributed during their risk window for acquisition of infection across shore assignment locations relative to general size of force concentrations (data not shown). When we assessed those Sailors who were assigned to sea duty during their calculated periods of risk for acquisition of HIV infection, the incidence of subsequent identification of HIV infection was lowest for crews of aircraft carriers and ballistic missile submarines (Fig. 2). Large deck amphibious vessels had the highest incidence of HIV compared to aircraft carriers [rate ratio (RR): 1.75; 95% CI: 1.09–2.80]. Although all other ship types, except ballistic missile submarines, had a higher incidence compared to the incidence on aircraft carriers, none reached

**TABLE II.** HIV Infection Incidence Across Navy Occupational Specialties

| | Incident HIV Cases 2005–2010 | | Cumulative Incidence | 95% CI | | |
|---|---|---|---|---|---|---|
| Rating | $n = 410$ | % | (Per 1000 Persons) | (Per 1000 Persons) | Risk Ratio | 95% CI |
| A | 8 | 2 | 9.39 | 4.02–18.25 | 9.29 | 4.63–18.67 |
| B | 32 | 8 | 4.39 | 3.10–6.30 | 4.51 | 3.01–6.27 |
| C | 2 | 0 | 4.31 | 0.52–15.42 | 4.26 | 1.07–17.05 |
| D | 21 | 5 | 4.10 | 2.59–6.12 | 4.05 | 2.61–6.32 |
| E | 10 | 2 | 3.86 | 1.85–7.06 | 3.82 | 2.04–7.17 |
| F | 79 | 19 | 3.36 | 2.67–4.16 | 3.33 | 2.59–4.28 |
| Other | 258 | 63 | 1.01 | 0.90–1.10 | 1.00 | — |

Cumulative incidence of the 6 Navy ratings with the highest HIV incidence using force strength statistics for 2006–2010. Other represents all other ratings not listed.

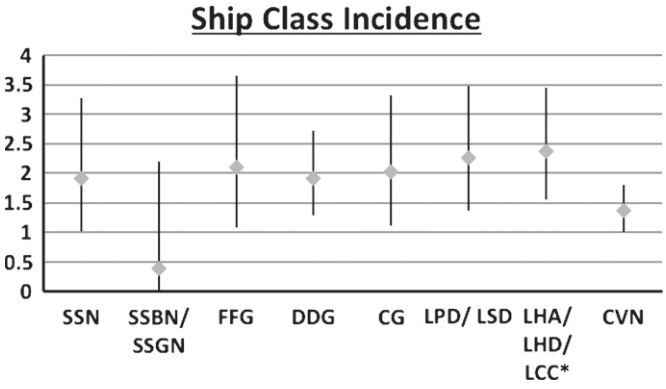


**FIGURE 2.** HIV infection incidence among Sailors who served on ships. Comparison of HIV acquisition risk window assignments and per ship class incidence. SSN = fast attack submarine. SSBN = ballistic missile submarine, counts including SSGN = guided missile submarine and variants. FFG = Frigate. DDG = Destroyer. CG = Cruiser. LPD/ LSD = small deck amphibious vessels. LHA/LHD/LCC = large deck amphibious vessels and control ships. CVN = aircraft carriers. *LHA/LHD/LCC had the largest and only statistically significant rate ratio when compared to CVN, RR 1.75, 95% CI 1.09 to 2.80.

statistical significance [RR: 1.41–1.75; 95% CI: 0.76–2.80]. For shore commands and among Marines, HIV infection density in general matched what might be expected with large concentrations of Sailors and Marines. Large bases had the greatest number of new infections (data not shown).

Among those Sailors and Marines with a history of deployment, how closely the IP HIV test occurred in relation to their last deployment varied by deployment type and service (Fig. 3). Figure 3 places the dates that these patients were last known to be HIV uninfected and first known to be HIV infected (HIV acquisition risk window) in the context of their last deployment start date. Any plot below the *x*-axis represents a last true negative HIV test result which precedes the deployment. Any plot to the right of the *y*-axis represents a first true positive which follows the beginning of the deployment. This lower right quadrant encompasses most deploying Sailors and Marines later identified as HIV infected. As time passes from the start of the deployment, the density in this quadrant decreases for both Sailors and Marines, most notably for those who had deployed to Iraq and Afghanistan. 53% of Marines and 57% of Sailors who had deployed to the wars in Iraq or Afghanistan were identified as HIV positive within 1 year of their deployment end date. The mean time from deployment start to first positive HIV test differed between those who deployed to Iraq or Afghanistan as compared to other theaters, 20 versus 29 months, respectively ($p < 0.001$).

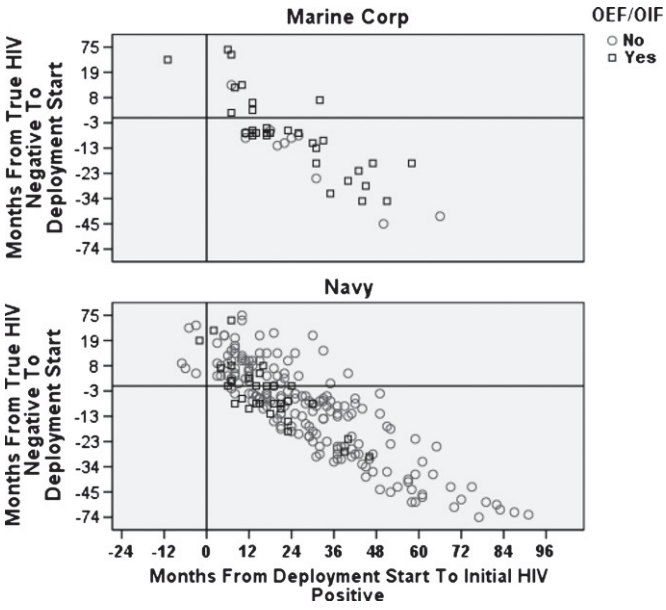


**FIGURE 3.** HIV infection risk windows and timing of deployment.

## DISCUSSION

Two important ideas emerge from this project: work factors are important in the acquisition of HIV infection in the military and HIV infection in the Navy is different than that in the Marine Corps.

This project revealed that the current HIV population in the Navy and Marine Corps differs from the HIV-infected service members previously described. Nearly half of this project's population self-reports as Black in contrast to less than a third as previously described, and the mean age of this population is 2 to 3 years younger.[2] The large fraction of infection occurring early in service suggests that the early enlistment period, in particular social and behavior patterns during occupational schools leading up to service in a first operational unit, merits closer investigation.

Although our analysis of occupational features was meant to explore hypotheses for further study, evidence for this also exists in disparities in disease count (rather than incidence) by rating and ship class. They are intriguing for the possibility of unique social networking which occurs in formative development in service as well as that contingent upon ship assignment, perhaps because of a mix of crew size, ship culture, operational tempo, and vessel homeport.

Sailors demonstrated different incidences of HIV infection by rating (Table II). Lateral transfer of HIV-infected Sailors during the period of interest was rare. The most prevalent rating, F, had not received any known HIV-infected Sailors by transfer. The combination of young age and short LOS together with clustering of infection in certain ratings implicates periods late in pipeline training and early post-training for HIV infection. They highlight the importance of promoting healthy social networks and sexual health habits during accession and training.

Rates of HIV infection amongst shore activities were not instructive. When ships were assessed, however, while assignment on larger vessels during the acquisition risk window contributed the highest number of later identified HIV infections, rates of subsequent infection were lowest among those who served on aircraft carriers and ballistic

missile submarines and highest on large deck amphibious ships. Whether this is a coincidence or service on these vessels convey variable risk because of social or other dynamics is not clear from this data.

Sailors and Marines deploy or take other assignments globally, move about the United States and have unique stressors. They are young and typically working in areas removed from family and other pre-existing support networks. Consequently, work specialization and assignment have a potentially large impact on the personal life of service members. In the deployment environment, unique occupational exposures are present both because of exposure to host nation citizens and potential use of the walking blood bank for exigent treatment of life-threatening trauma.[10,11]

Our data suggest that deployment must be further explored as a potentially important event predisposing to HIV infection. Figure 3 illustrates this. Predeployment, on deployment, and postdeployment time periods may be important particularly for those who had deployed to Iraq and Afghanistan. Personnel who deployed to Iraq and Afghanistan were identified as HIV infected earlier than their counterparts who deployed to other theaters of operation. However, that difference may have been confounded by more stringent processes regarding the collection of postdeployment serum samples after deployment to Iraq and Afghanistan.

Though anchored with conventional contributing risks such as alcohol consumption and prior casual sex, the idea of contranormative situations leading to disinhibition in nonmilitary settings has been published.[12] In the setting of spring break, this has been further explored to examine whether peers predefine acceptable behavior before going on vacation.[13] These concepts may have analogs with liberty port, perideployment leave and liberty, temporary assigned duty, deployment activities, new accession to service and first assignments. Such relationships could have marked impact on relevance of targeted prevention measures to include administrative controls.

Although served by the same medical department, this report is the first to clarify HIV demographic differences between the Navy and Marine Corps. Sailors and Marines had some similarities but also fundamental differences in their demographics which could impact prevention measures and require service specific interventions. This also was true between different Sailor occupational specialties.

HIV-infected Sailors and Marines identified during the study period had similar distributions of age at IP test, length of service, and self-reported race. However, force differences in incidence as well as differences in region of birth, HOR, and deployment patterns (Table I), potential for contribution of occupational specialty (Table II) and assignment type (Fig. 2) suggest that patterns of HIV acquisition in the two services differ. Southern birth among Sailors was twice as prevalent as among Marines, and particularly high in rating (occupational specialty) B. Rating wide demographics may confound this observation. Consequently, prevention and screening practices may need to be tailored not only by service, but within the Navy by rating. Military wide, approximately nearly one in three military accessions entered from southern states from 2005 through 2010 (personal communication, Navy Recruiting Command).

Recently reported U.S. incidences of HIV are not age adjusted and more than a third of HIV cases occur in age groups not represented by active duty personnel. This may contribute to why Navy HIV incidence is higher and Marine Corps incidence comparable to that estimated in the total civilian population in the United States (roughly 0.2 per 1,000 persons across 2006–2009), though the Navy employs universal screening and 1 in 5 U.S. civilians who live in high HIV disease burden areas are infected and may not be aware of their HIV infection status.[14,15] Previous U.S. estimates reported rates of 0.27 to 0.43 per 1,000 persons among age groups of military interest.[16] Those individuals self-identifying as Black, or Hispanic, and men who have sex with men continue to disproportionately represent incident U.S. HIV infections.[14] Self-reported Black Sailors and Marines constitute nearly half of incident HIV infections. In contrast, the fraction of Hispanic Sailors and Marines among those with incident HIV infections is comparable to the force distribution of Hispanic Sailors and Marines overall. The Defense Equal Opportunity Management Institute reported that as of September 2010, active duty Black and Hispanic enlisted service members comprised approximately 20% and 17% of Sailors, 11% and 14% of Marines.[17]

## LIMITATIONS

Control data with non-HIV infected service members was not part of this project. Non-equal opportunity demographic force data was not available. For instance, anecdotally, the Navy recruits most heavily from the South and all services differ in their geographic composition. However, specific data on this was not available to the investigators. Ship assignment incidences employed denominator data which did not incorporate embarked Marines or aircraft components such as carrier air wings, Marine elements, or Navy helicopter detachments. Also, Sailors had exposures other than ship assignment.

## CONCLUSIONS

The Navy and Marine Corps have different patterns of HIV infection which may merit distinct approaches to prevention. The Navy in particular may have unique targets for prevention efforts to include pipeline training and first assignment as well as particular occupational environments. Proactive operational research is required to further elucidate the nature of these acquisition dynamics en route to tailored prevention and surveillance strategies which maintain the health of the fighting force. Influences that predate accession into the services, potential role of occupational rating populations and pipelines, the impact of deployment and the role of occupational settings such as ship assignment should be further explored.

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