

Prevalence of *Helicobacter pylori* in United States Navy submarine crews

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(Accepted 1 July 2005, first published online 30 September 2005)

SUMMARY

Helicobacter pylori prevalence is elevated in German submarine crews and in United States Navy (USN) surface fleet personnel, but *H. pylori* prevalence in USN submariners was unknown. The goal of the study was to determine the prevalence of *H. pylori* in the crews of USN nuclear submarines compared to other military personnel and to the general US population. The presence of *H. pylori* IgG antibodies was determined in serum samples using a commercial ELISA. Only 47 out of 451 submariners (9.4%) were *H. pylori* positive, which is similar to that of the US general population with a similar level of education. In contrast, *H. pylori* prevalence is significantly higher in US Army recruits (26%), USN surface fleet personnel (25%), and German diesel submariners (38%). These data demonstrate that submarine service (and by inference activity requiring isolation and close contact, *per se*) is not a risk factor for *H. pylori* infection.

INTRODUCTION

United States Navy (USN) submarine crew members are highly trained and highly educated. Until recently, the diagnosis of peptic ulcer disease (PUD) was considered disqualifying for submarine duty because of the increased risk of bleeding and perforation during long-term missions. Such disqualification resulted in substantial replacement costs [1, 2]. Preventing the occurrence of PUD in submarine crew members or treating the disease in such a way as to prevent recurrence has significant implications on

disqualification policy and would result in considerable benefits for the USN submarine community.

The discovery of the relationship between *Helicobacter pylori* and PUD has revolutionized management of the disease. *H. pylori* is now recognized as a major aetiological agent in chronic active gastritis and in the pathogenesis of duodenal ulceration [3]. As a result of these developments, the Navy's Bureau of Medicine and Surgery has modified the regulation disqualifying candidates with PUD; it now specifies that submariners with a history of *H. pylori*-related PUD in whom the infection has been eliminated by antibiotics can be returned to duty [4]. However, the usefulness of the revised regulations depends on knowing prevalence rates of *H. pylori* infection among submarine crews and assessing potential risks for re-exposure on board ship following eradication.

The prevalence of *H. pylori* infection in the USN submarine community is unknown, but it is almost twice as high in German submariners compared to

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The opinions and assertions expressed in this paper are those of the authors and are not to be construed as official or reflecting the views of the Department of the Navy, the Uniformed Services University of the Health Sciences, the Department of Defense, or the US Government.

Table 1. Prevalence of anti-*Helicobacter pylori* IgG antibody among 449 USN submariners by age and ethnicity

Group	Number of men in group (%)	Prevalence estimate	95% CI	Mean years submarine duty
Ethnicity				
Caucasian	381 (84.7)	5.9%	0–13	6.10 ± 5.28
African American*	39 (8.7)	33%	0–73	5.15 ± 4.94
Hispanic†	14 (3.1)	20.2%	0–50	5.14 ± 3.82
Other	16 (3.5)	7.5%	0–19	7.25 ± 6.19
Age (years)‡				
Mean age 27	449	9.4%	0–19	6.01 ± 5.23
17–24	176 (39.2)	9.8%	0–21	2.04 ± 1.18
25–34	198 (44.1)	7.5%	0–16	6.71 ± 3.86
≥ 35	75 (16.7)	10.5%	0–23	13.54 ± 5.16

CI, Confidence interval.

* $P < 0.001$ when compared to Caucasians.

† $P = 0.095$ when compared to Caucasians.

‡ $P > 0.05$ for all age groups.

their Air Force colleagues [5]. Given the new USN ulcer waiver policy on *H. pylori* eradication and the association of ulcers with *H. pylori* infection, it is important to determine whether *H. pylori*-negative submariners granted waivers to return to sea duty are being exposed to a high-risk environment similar to that apparently present in German submarines [5].

Here, we report on the prevalence of *H. pylori* infection among USN nuclear submarine crews as compared to that observed in the general military and US civilian populations. The present observations may be relevant to similar environments where rescue or extraction would be difficult such as long-term polar missions and space exploration.

METHODS

Subjects

The study included 451 male active-duty personnel serving on submarines. Average age was 27 years with a range of 18–55 years. Caucasians comprised 85% of the volunteers and African Americans made up most of the remainder at 8.7%. Mean age and ethnicity is consistent with USN submariner demographics [6]. Eight submarines, each with a complement of ~100–110 crew members, were approached for participation; the per cent of the available crew members that volunteered from each boat varied from 16 to 100%. The volunteers consisted of 215 submariners from five fast attack submarines stationed at the Naval Submarine Base in Groton, CT, and 236 from three ballistic missile submarines stationed

at the Naval Submarine Base in Kings Bay, GA. Ballistic missile submariners deploy for 3 months at a time and are strictly at sea during their deployment; the fast attack deployments are more flexible and variable, but the demographics of the two types of crews is similar [6, 7]. Controlling for the differing deployment styles was the reason for acquiring equal numbers in the study group. Demographic and prevalence characteristics of the study population are listed in Table 1.

All procedures followed were approved and performed in accordance with the ethical standards set forth by the Committees to Protect Human Subjects at the Naval Submarine Medical Research Laboratory and at the Naval Medical Research and Development Command. Each subject prior to enrolment in the study signed an informed consent form.

Procedures

A 10-ml blood sample was collected from each subject to determine *H. pylori* prevalence. The serum was separated and stored at -15°C . Serum samples were tested for *H. pylori* IgG antibody with a commercial enzyme-linked immunosorbent assay (ELISA) that uses a partially purified *H. pylori* antigen with a sensitivity of 99% and a specificity of 98% (Pylori Stat[®] test kit, Wampole Laboratories, Cranbury, NJ, USA) [8].

Questionnaires were administered to all volunteers. These included demographic information and details of submarine duty.

Table 2. Comparison of *Helicobacter pylori* prevalence between USN fleet personnel and USN submariners

Group	Submariners	Fleet personnel	
Age (years)			
17–24	11.4% (20/176)	27.2% (182/802)	$P < 0.001$
25–34	9.1% (18/198)	30.0% (51/170)	$P < 0.001$
≥35	12.0% (9/74)	50.0% (14/28)	$P < 0.001$
Ethnicity			
African Americans	33.3% (13/39)	46.4% (78/168)	$P < 0.001$
Caucasians	7.6% (29/381)	17.5% (128/730)	$P < 0.001$

Data analysis

Observed prevalence was calculated from the results of *H. pylori* serology. Adjusted prevalence estimates, incorporating the sensitivity and specificity of the *H. pylori* serology test, were calculated by the method of Cochran & Cox [9]. This method uses the crude observed prevalence and group size to produce both an unbiased true prevalence estimate and variance of this estimate.

Statistical analysis

Subgroups of interest (e.g. ethnicity) were analysed in contingency tables. The three age groups used were chosen for direct comparison to Hyams' study of *H. pylori* in USN surface fleet personnel [10]. A two-tailed Pearson's χ^2 with Yates correction was used to test the independence of categorical risk factors; $P < 0.05$ was considered significant. For groups with frequencies < 5 , Fisher's exact test was used. For continuous variables (e.g. length of service), linear regression analyses were performed to examine correlation of *H. pylori* presence in various groups.

RESULTS

H. pylori prevalence

Of 451 submariners, 47 (10.4%) were positive for *H. pylori* IgG antibody, 402 (89%) were *H. pylori* negative, and two (0.5%) were equivocal. These latter two subjects were excluded from further analysis. Estimated true prevalence for the total group was 9.4% with a 95% confidence interval of 0–19.

Prevalence estimates by ethnic group and age are presented in Table 1. The four ethnic groups did not differ in the number of years of active duty or submarine duty. However, *H. pylori* prevalence was significantly higher in African American compared

to Caucasian submariners ($\chi^2 = 23.2$, $P < 0.001$), but not in Hispanics compared to Caucasians (Fisher's exact test, $P = 0.095$).

There was no significant difference in prevalence between the two types of submarines (data not shown) or among the three age groups (Table 1), despite the positive correlation of age and *H. pylori* infection in the general population [11]. Because *H. pylori* prevalence has been shown to vary as a function of ethnicity, level of education (a marker of socio-economic level), and age [11–13], a subgroup analysis of *H. pylori* epidemiology in submariners was performed. This analysis revealed that the prevalence increased significantly with age in African Americans [17–24 (20%), 25–34 (38%), ≥35 (60%); $P < 0.05$] but not in Caucasians [17–24 (6%), 25–34 (2%), ≥35 (4%); $P > 0.05$]. Level of education had an effect on prevalence in African Americans aged 25–34 years but not in other age groups. Interestingly, the prevalence was higher in African Americans aged 25–34 and ≥35 years compared with Caucasians in the same age groups, but ethnic origin had no significant effect in the 17–24 years age group.

Although *H. pylori* prevalence was more than twice as high in enlisted men compared with officers, this difference did not reach statistical significance, possibly due to the small number of officers tested (Fisher's exact test, $P = 0.40$). Similarly, level of education, smoking and region of birth did not have a statistically significant effect on *H. pylori* prevalence.

To corroborate the analysis of age as a categorical variable, *post-hoc* regression analyses (using age as a continuous variable) demonstrated no overall correlation between age or years of service and *H. pylori* status.

Table 2 illustrates the prevalence and statistical comparisons with published data on other military populations. *H. pylori* prevalence was significantly

lower in USN submariners compared with other military populations.

DISCUSSION

The present study demonstrates that the estimated true prevalence of *H. pylori* in personnel assigned to duty in USN nuclear submarines is 9.4%. This is less than half the prevalence observed in USN (surface) deployable fleet personnel (25%) and US Army recruits (26%) [10, 14]. Thus, USN submariners have a markedly lower *H. pylori* prevalence than that of other US military populations that have been studied as recently as the 1990s [5, 10, 14]. This observation could be due to differences in age, gender (currently all submariners are male), ethnic origin, time between observations, and socio-economic differences.

To further explore those differences, a comparative subgroup analysis of data from USN surface fleet personnel (individual data kindly provided by Dr Hyams) and from submariners was performed. Interestingly, only 8% of service members in the Hyams' study had more than high-school education, while 50% of submariners had more than high-school education. Thus, the higher prevalence in the surface fleet could be related to their lower level of education, as an indicator of socio-economic status. Another potentially important factor is that surface fleet personnel are more frequently deployed to foreign countries where *H. pylori* prevalence is higher than in the United States [11, 15].

We also compared *H. pylori* prevalence in submariners and in the US general population. Hopkins et al. found 8% *H. pylori* prevalence in Caucasians aged 20–29 years, and 38% in African Americans aged 20–29 years [16]. This similarity supports the premise that demographic differences between submarine and surface fleet crews appear to be the primary determinants of the differing levels of *H. pylori* prevalence. The Third National Health and Nutrition Examination Survey (NHANES III) demonstrated that *H. pylori* prevalence in Caucasians was ~10% for the 20–29 years age group, 20% for the 30–49 years group, and 20% for the 50–59 years group [13]. Interestingly, *H. pylori* prevalence was only 9% in the 40–49 years group of suburban professionals, close to that observed in the present study.

Interpretation of our results must be qualified by the fact that in the present study, the diagnosis of *H. pylori* was based solely on serology. Serological

tests for *H. pylori* antibody are highly sensitive and specific for active infection but seroconversion generally occurs after a 3–6 months delay [17–20]. It is also possible that the low prevalence of *H. pylori* observed in USN submariners is related to the fact that the USN, in the past, disqualified submariners with a history of PUD.

In conclusion, the present study indicates that USN submariners have a low overall *H. pylori* prevalence that is comparable to that observed among the ethnic and socio-economic groups from which they originate. In addition, *H. pylori* prevalence for Caucasians and African Americans with more than a high-school education does not increase with years of service. Thus, service in nuclear submarines does not appear to increase the risk of *H. pylori* infection, as had been suggested by earlier studies of diesel submarine crews in Germany [5]. These data support the premise that returning USN submariners back to duty should have no deleterious consequences and that the environment will not be one that places them at heightened risk for re-infection with *H. pylori*. The results and conclusions of this study may be relevant to analogous settings such as the Merchant Marine, recreational cruise ships, and civilian expeditions that require close contact and isolation such as Antarctic or polar missions, space or air travel, and living in an underwater habitat.

ACKNOWLEDGEMENTS

This project was conducted under Naval Medical Research Development Command Research Work Unit 63706N-M0096.002-5205, Medical Conditions Affecting Submarine Qualifications. Supported in part by grant R01 CA82312 from the National Institutes of Health. The authors extend thanks to all those who aided, critiqued, and otherwise helped in the preparation of this paper.

DECLARATION OF INTEREST

None.

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