# A Multivariate Analysis of Factors Associated with Differential Disease and Nonbattle Injury and Morbidity Aboard Ships of the U.S. Naval 5th Fleet during Peacetime Deployment

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**Disease nonbattle injury (DNBI) surveillance is a critical component of U.S. military force health protection and has been aggressively implemented by the U.S. Central Command. This study presents a multivariate analysis of factors associated with DNBI incidence rates as well as a description of morbidity measures associated with DNBI from U.S. Navy ships deployed to the Middle East from October 2000 through September 2001. Weekly DNBI reports ($N$ = 331) from a total of 44 individual units representing six different classes of U.S. Navy ships were included in the analysis. There were statistically significant differences in summary and categorical DNBI rates associated with ship class, season, and presence of female sailors embarked. The top three DNBI categories associated with the most lost workdays because of sick in quarters and hospitalization were other medical/surgical (36%), infectious gastrointestinal (23%), and all types of nonbattle injury combined (17%).**

## Introduction

The use of surveillance systems to reveal disease outbreaks, changing trends, and distributions of disease and nonbattle injuries (DNBI) among deployed military personnel is a critical component for maintaining a healthy fighting force. These operational-based surveillance systems provide real-time monitoring of health indicators among deployed ships where resupply and augmentation capabilities are often constrained.

In 1997, the Department of Defense developed and mandated a surveillance system to collect and report weekly DNBI events for initial outpatient visits, sick in quarters (SIQ) days, light duty days, hospital admissions, and hospital bed days among forward deployed units by disease or injury category.[1]

In a retrospective cohort analysis of aggregate shipboard DNBI surveillance data that was recently published, weekly DNBI reports ($N$ = 233) were received from six different ship classes during an unknown period beginning in February 2000.[2] The authors demonstrated wide-ranging differences in crude DNBI incidence rates between ship types and proposed a number of factors, including operational tempo, seasonality, and manning, but did not evaluate their impact. This preliminary analysis demonstrated the need for further study of the factors associated with different DNBI patterns among different ship types.

Additional published studies have reported that ship size was an important predictor of divergent DNBI rates, with overall rates of illness, upper respiratory disease, acute gastrointestinal infection, musculoskeletal injury, dermatologic, behavioral, and sexually transmitted disease incidence rates consistently lower for larger ships.[3-6] Limited investigations have described differences in DNBI rates among ships with female sailors onboard.[8-10] In one study of 26 auxiliary and 6 combatant ships, women accounted for 39% of the medical departments' daily caseload, but the study failed to report the percentage of the crew that was female.[10]

Few reports exist that provide any description of DNBI-related morbidity (i.e., light duty days, SIQ days, hospital admissions, and hospital bed days).[11-14] One study reported overall hospital admission rates among 209 ships ranged from 0.9 to 2.9 admissions per 1,000 person-weeks.[11] Mental disorders, acute gastrointestinal (GI) illnesses, poisonings, and violence accounted for the largest proportion of shipboard hospital admissions. An additional study reported that among data collected from 1977 to 1979, carriers, cruisers, and destroyers all had accidental injury hospitalization rates significantly higher than the Navy-wide average.[13]

Limitations of previous studies include the variety of surveillance methods used (making comparative studies impractical), the use of data that are more than 20 years old, data collected from a limited number of ships over short durations, and a paucity of investigations on DNBI morbidity measurements.

To expand the understanding of health among deployed military personnel, we compiled descriptive epidemiological information on DNBI incidence from deployed U. S. Navy ships in the Middle East from October 2000 to September 2001. The data we compiled partially overlaps a recently published study by Bohnker et al.[2] However, limitations of that study include the exclusion of other factors likely associated with differential DNBI rates, potential inefficiency and bias associated with statistical analyses of count data using linear model assumptions, and lack of adjustment for variability in unit size and nonindependence among individual ship reports.

The primary objectives of our study were to statistically compare deployed shipboard DNBI rates to the published Joint Chiefs of Staff (JCS) referent DNBI rates and to assess putative associations between DNBI rates and ship class, seasonality, and the presence of female crew aboard ship using an appropriate statistical model for count data. Last, we describe morbidity

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measurements associated with categorical and summary DNBI visits among this deployed shipboard population.

## Methods

Beginning in February 2000, the Commander of U.S. Naval Forces Central Command instituted a weekly DNBI incident morbidity surveillance system for all ships within his area of responsibility. This required each ship to submit an aggregate DNBI report (standardized spreadsheet format) to the Fleet Surgeon's office colocated with the Commander of U.S. Naval Forces Central Command. The Fleet Surgeon's office collated all weekly reports and forwarded them to the Navy Environmental and Preventive Medicine Unit 7 located in Sicily, Italy. Each week, Navy Environmental and Preventive Medicine Unit 7 personnel conducted trend analysis, compiled a summary, and reported back to the Fleet Surgeon's office any significant changes in DBNI rates.

For this study, weekly initial DNBI visit count data were abstracted for the period covering October 2000 through September 2001 for each ship. Integrity checks were conducted on all data to ensure validity. Data on initial visits for 15 DNBI categories were compiled at the individual ship level, and event data on morbidity measures for each DNBI categories were aggregated for all reporting ships on a weekly basis. Data on variables including total number of shipboard personnel, week of calendar year, number of female sailors aboard, and class of ship for each report were also abstracted. In addition, the four DNBI categories of injury (not including heat/cold injury) were collapsed into a total injury category, and DNBI categories of combat/operational stress and other psychiatric disorders were collapsed into a single category of mental health.

The primary outcome (mean weekly initial visit rates per 1,000 sailors for each DNBI category) was estimated for all ships during the 52-week period using negative binomial regression modeling DNBI visit counts with person-weeks as exposure. A negative binomial model was chosen because of the nature of the count data and evidence of overdispersion in application of the Poisson regression model. In addition, because an individual ship could provide more than one weekly report during the surveillance period, the assumption of independence among observations could be violated and was addressed by adding correction for repeated measures by specifying the individual ship unit as a cluster in all models.[15] For all categorical DNBI initial visit counts, except gynecological, the exposure was based on the weekly total force of the reporting unit. For gynecological initial visits, calculations where limited to ships that had women onboard and the exposure was the weekly female force aboard ship. Because one of the ship classes (frigates) did not have any weekly reports where there were females aboard, the gynecological initial visit rate estimation excluded this ship class. Furthermore, total DNBI visit rates were estimated excluding the gynecologic visits so as to be able to compare this rate for all six classes. Categorical and summary DNBI initial visit rates for each stratum of ship class were similarly estimated.

Univariate analysis was performed to determine the effect of ship class, percentage of female crew aboard ship (POFCAS), and season on the primary outcomes using the negative binomial regression model. To determine the effect of ship class, summary and categorical initial DNBI visits were estimated by modeling ship class as a multilevel categorical variable and comparing the five ship class categories to the carrier. To evaluate the effect of season on the attack rates, weeks were collapsed into months and quarters and mean initial visit DNBI rates were plotted against these groups. Based on this analysis and recognition of climatologic features of the area of operation (Persian Gulf), the calendar year was dichotomized into two seasons: summer (extremely hot), lasting from April to October, and winter (relatively mild), lasting from November to March. The POFCAS was computed for those ships to which women were assigned and was found to be linearly related with several DNBI categories. This continuous variable was categorized into equal quartiles of percent female force and was analyzed as an ordinal variable of POFCAS.

For each DNBI category, if two or more of the predictor variables were found to be independently associated ($p < 0.2$), a multivariable negative binomial regression model was performed with each variable included in the model. The frigate ship class was excluded from all multivariate modeling, as this class did not report women present for any weekly report. Excluding frigates in the univariate analysis did not significantly change any of the associations (data not shown). For dichotomous and ordinal variables in the univariate and multivariate models, an incidence rate ratio (IRR) was calculated as the effect measurement statistic.

Morbidity outcomes of SIQ days, light duty, hospital admissions, and hospital bed day rates per 1,000 person-weeks from all reporting units were compiled and analyzed at the weekly aggregate level by summing the total number of events by person-time of exposure. A severity index (SI) was created based on the number of SIQ days, light duty days, hospital admissions, and total days lost per 100 initial visits for each respective DNBI category; this information was then summarized. Statistical significance for all associations was set at $p = 0.05$. All analysis was performed using Stata Version 8.0 (College Park, TX).

## Results

Weekly DNBI reports ($N = 331$) from a total of 44 individual ships representing six different classes of U.S. Navy ships were included in the analysis (Table I). DNBI reports were submitted for all weeks except for the week of September 3–9, 2001. A total of 339,162 person-weeks of data was collected with average weekly combined ship strength of 6,650 persons. Sixteen (36.3%) of the 44 ships reported female sailors onboard, representing a total of 29,448 person-weeks (8.7%) of the total person-weeks of data analyzed. Reports were collected from 5 carriers, 7 amphibious assault ships, 6 cruisers, 18 destroyers, 3 combat support ships, and 5 frigates.

The total weekly initial visit DNBI rate excluding gynecological visits was 41 initial visits per 1,000 person-weeks and did not differ statistically from the JCS referent rate of 40 initial visits per 1,000 person-weeks (Table II). We found a number of categorical DNBI initial visit rates higher than the JCS referent rates, including dermatologic, gynecologic, ophthalmologic, respiratory, and unexplained fever. However, several categorical DNBI rates were significantly lower, including infectious GI disease, heat/cold injury, combat/operational stress, sexually transmitted disease, and all categories of injury. The DNBI cat-

TABLE I

CHARACTERISTICS OF WEEKLY DNBI REPORTING FROM U.S. NAVY 5TH FLEET FROM OCTOBER 2000 TO SEPTEMBER 2001 BY SHIP CLASS

| Ship Class | Units in Class | Person-Weeks | Female Person-Weeks | Women Aboard (n/N) | Mean Female Force (% of Ship Force) |
|---|---|---|---|---|---|
| Carrier | 5 | 222,814 | 19,947 | 5/5 | 443 (9) |
| Amphibious assault | 7 | 37,480 | 3,706 | 5/7 | 90 (14) |
| Cruisers | 6 | 19,222 | 496 | 4/6 | 23 (6) |
| Destroyers | 18 | 38,524 | 3,311 | 12/18 | 44 (13) |
| Combat support | 3 | 12,127 | 1,863 | 3/3 | 85 (15) |
| Frigates | 5 | 8,995 | 0 | 0/5 | NA[a] |
| Total | 44 | 339,153 | 29,334 | 29/44 | 142 (12) |

[a] NA, Not applicable.

TABLE II

SUMMARY DNBI INITIAL VISIT RATES FOR ALL SHIPS REPORTING

| DNBI Category | Initial Visit Rate[a] (Mean [95% CI]) | Bohnker et al.[2] Initial Visit Rate[a] (Mean) | JCS Referent DNBI Rate[b] (Mean) |
|---|---|---|---|
| Dermatologic | 7.4 (6.0, 9.0) | 8.9 | 5 |
| GI, infectious | 3.0 (2.2, 4.2) | 4.8 | 5 |
| Gynecologic[c] | 14.5 (10.7, 19.7) | 19.4 | 5 |
| Heat/cold injury | 0.3 (0.2, 0.6) | 0.4 | 5 |
| Injury, total | 9.4 (7.8, 11.3) | ND[d] | ND |
| Recreational | 1.8 (1.3, 2.5) | 1.6 | 10 |
| Motor vehicle | <0.01 (0, 0.02) | <0.01 | 10 |
| Working | 5.2 (4.2, 6.5) | 4.3 | 10 |
| Other | 2.4 (1.7, 3.4) | 1.9 | 10 |
| Ophthalmologic | 1.7 (1.5, 1.9) | 2.5 | 1 |
| Mental health | 1.3 (0.9, 2.1) | ND | ND |
| Combat/operational stress | 0.2 (0.1, 0.4) | <0.1 | 1 |
| Other psychiatric disorders | 1.2 (0.8, 1.9) | 1.4 | 1 |
| Respiratory | 7.4 (5.8, 9.6) | 6.5 | 4 |
| Sexually transmitted disease | 0.3 (0.2, 0.5) | <0.1 | 5 |
| Fever, unexplained | 0.05 (0.03, 0.9) | 0.2 | 0 |
| Other, medical/surgical | 11.1 (9.1, 13.7) | 13.6 | ND |
| Total DNBI[e] | 41.1 (36.0, 47.0) | 43.8 | 40 |

[a] Initial visits per 1,000 person-weeks.
[b] JCS suggested referent rates (initial visits per 1,000 person-weeks).
[c] Rate calculated as initial visits per 1,000 female person-weeks.
[d] ND, Not described.
[e] Excludes gynecologic events.

egories of gynecologic, other medical/surgical, and total injury were among the highest (14.5, 13.7, and 9.4 visits per 1,000 person-weeks, respectively). The rate of "other psychiatric initial visits" was the only DNBI category other than total DNBI that did not differ significantly from the JCS referent rates.

Several differences were noted between the summary rates we report and those reported by Bohnker et al.[2] Table II compares our DNBI category rate estimates next to the original rate estimates (DNBI rates of Bonkher et al. have been transformed from events per 100 person-weeks to events per 1,000 person-weeks for comparability). In general, we report lower rate estimates across DNBI categories except for those related to injury and respiratory illness. The confidence intervals for our rate estimates include the point estimates from the original study except for DNBI categories of infectious GI disease and opthalmologic visits.

Ship class was significantly associated with all categorical and total DNBI initial visit rates except other medical/surgical (Table III). Because of a lack of events, the association between ship class and motor vehicle injury and unexplained fever could not be evaluated statistically. Total initial visit DNBI rates were highest aboard the fast combat support ships and lowest aboard the frigates (56 vs. 19 initial visits per 1,000 person-weeks), and the differences among ship classes were statistically significant ($p = 0.02$).

In univariate analysis of the season as a predictor, we found that gynecologic, other injury, respiratory, and other medical/surgical initial visit rates were higher in the winter compared with summer ($p = 0.01$, $p = 0.02$, $p = 0.003$, and $p = 0.001$, respectively; Table IV). Only heat/cold injury was found to be significantly higher in the summer ($p < 0.001$) at a rate of more than 21 times that found in the winter. Sexually transmitted disease rates in the summer were nearly twice that in the winter, approaching statistical significance (IRR, 1.9; $p = 0.08$).

DNBI categories found to have higher rates associated with increasing POFCAS included infectious GI disease, ophthalmologic, other psychiatric, and other medical/surgical. A small, nonstatistically significant increase in total DNBI initial visit

TABLE III

SUMMARY AND CATEGORICAL DNBI INITIAL VISIT RATES BY CLASS OF SHIP

| DNBI Category | DNBI Initial Visit Rates ($n$/1,000 person-weeks) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Carriers | Amphibious | Cruisers | Destroyers | Combat Support | Frigates | $p$[a] |
| Dermatologic | 10.6 | 6.7 | 6.5 | 5.9 | 12.2 | 4.2 | <0.001 |
| GI, infectious | 4.4 | 4.5 | 0.6 | 3.3 | 1.7 | 0.6 | <0.001 |
| Gynecologic | 15.9 | 7.3 | 9.2 | 16.7 | 20.3 | NA[b] | 0.01 |
| Heat/cold injury | 0.1 | 0.6 | 0.4 | 0.3 | 0.2 | 0.3 | 0.06 |
| Injury, total | 7.6 | 11.0 | 6.4 | 11.4 | 14.9 | 4.0 | <0.001 |
| Recreational | 0.9 | 1.2 | 2.0 | 2.8 | 2.6 | 0.9 | <0.001 |
| Motor vehicle | <0.01 | NE[c] | NE | NE | NE | 0.1 | |
| Working | 5.5 | 6.4 | 3.5 | 5.4 | 7.4 | 1.6 | <0.001 |
| Other | 1.3 | 3.0 | 0.9 | 3.1 | 4.9 | 1.3 | 0.05 |
| Ophthalmologic | 2.0 | 1.9 | 1.1 | 1.4 | 1.9 | 0.8 | 0.15 |
| Mental health | 3.2 | 0.8 | 0.7 | 0.9 | 0.9 | 0.1 | <0.001 |
| Combat/operational stress | 0.4 | 0.1 | 0.1 | 0.1 | 0.2 | NE | <0.001 |
| Other psychiatric disorders | 2.8 | 0.7 | 0.7 | 0.8 | 0.7 | 0.1 | 0.002 |
| Respiratory | 5.4 | 6.5 | 8.5 | 9.2 | 10.2 | 3.3 | 0.01 |
| Sexually transmitted disease | 0.4 | 0.3 | 0.2 | 0.1 | 1.1 | 0.2 | <0.001 |
| Fever, unexplained | 0.1 | 0.1 | NE | 0.1 | NE | NE | |
| Other, medical/surgical | 15.2 | 12.1 | 11.1 | 9.7 | 12.6 | 5.7 | |
| Total DNBI[d] | 49 | 43 | 36 | 42 | 56 | 19 | 0.02 |

[a] Negative binomial regression modeling categorical variable of ship class against carrier.
[b] NA, Not applicable.
[c] NE, No events.
[d] Excludes gynecologic visits.

TABLE IV

UNADJUSTED INITIAL VISIT DNBI INCIDENT RATE RATIOS BY SEASON OF THE YEAR AND INCREASING QUARTILES OF POFCAS

| DNBI Category | Season | | Increasing quartiles of POFCAS | |
|---|---|---|---|---|
| | IRR (95% CI)[a] | $p$ | IRR (95% CI)[b] | $p$ |
| Dermatologic | 1.2 (0.9, 1.5) | | 1.1 (0.9, 1.4) | |
| GI, infectious | 1.2 (0.8, 2.0) | | 1.3 (1.0, 1.7) | 0.03 |
| Gynecologic | 0.6 (0.4, 0.9) | 0.01 | 1.4 (0.9, 2.1) | 0.17 |
| Heat/cold injury | 21.8 (5.2, 91.7) | <0.001 | 0.9 (0.5, 1.6) | |
| Injury, total | 1.0 (0.7, 1.4) | | 1.0 (0.9, 1.2) | |
| Recreational | 0.7 (0.4, 1.2) | 0.18 | 0.7 (0.5, 1.0) | 0.06 |
| Motor vehicle | 0.5 (0.1, 3.4) | | 0.8 (0.4, 1.6) | |
| Working | 1.3 (0.9, 1.8) | 0.15 | 1.1 (0.9, 1.4) | |
| Other | 0.8 (0.5, 1.4) | 0.02 | 1.1 (0.8, 1.5) | |
| Ophthalmologic | 0.9 (0.6, 1.1) | | 1.2 (1.0, 1.4) | 0.02 |
| Mental health | 1.0 (0.6, 1.6) | | 1.3 (1.0, 1.7) | 0.07 |
| Combat/operational stress | 2.6 (0.5, 15.5) | | 0.7 (0.3, 1.2) | 0.19 |
| Other psychiatric disorders | 0.9 (0.6, 1.3) | | 1.4 (1.1, 1.8) | 0.01 |
| Respiratory | 0.6 (0.4, 0.8) | 0.003 | 1.1 (0.8, 1.4) | |
| Sexually transmitted disease | 1.9 (0.9, 3.9) | 0.08 | 1.5 (1.0, 2.2) | 0.06 |
| Fever, unexplained | 2.5 (0.8, 8.1) | 0.1 | 0.7 (0.4, 1.1) | 0.13 |
| Other, medical/surgical | 0.8 (0.6, 1.1) | 0.001 | 1.1 (0.9, 1.4) | 0.17 |
| Total DNBI[c] | 0.9 (0.7, 1.1) | | 1.1 (1.0, 1.2) | 0.06 |

[a] Incidence rate ratio = rate summer/rate winter.
[b] Incidence rate ratio = increasing quartiles of percentage of female crew aboard ship (ordinal).
[c] Excludes gynecologic visits.

rate, excluding gynecologic rates, was found to be associated with increasing POFCAS (IRR, 1.1; $p = 0.06$). No DNBI category was found to have a statistically significant lower initial visit rate with increasing POFCAS, although recreational injury tended toward statistical significance (IRR, 0.7; $p = 0.06$).

Table V summarizes the results for each DNBI category of initial visits when two or more independent variables were found to be statistically associated in the univariate models (inclusion = $p < 0.2$). Among cruisers and combat ships, a decreased rate of infectious GI visits (IRR, 0.2; $p > 0.0001$; IRR, 0.3; $p < 0.0001$, respectively) was noted. Decreased gynecologic initial visit rates were associated with the amphibious ship class (IRR, 0.4; $p = 0.008$), but increased rates tended toward an association with increasing POFCAS (IRR, 1.5; $p = 0.06$). Overall mental health-

TABLE V

*MULTIVARIATE ANALYSIS OF DNBI INITIAL VISIT RATES OF SIGNIFICANT UNIVARIATE INDEPENDENT VARIABLES*

| DNBI Category | Variable | IRR[a] | 95% CI | *p* | Other Nonsignificant Variables |
|---|---|---|---|---|---|
| GI, infectious | Cruiser | 0.2 | 0.1, 0.4 | <0.0001 | Amphibious, destroyer |
| | Combat support | 0.3 | 0.2, 0.6 | <0.0001 | |
| | POFCAS[b] | 1.2 | 1.0, 1.5 | 0.07 | |
| Gynecologic | Amphibious | 0.4 | 0.2, 0.8 | 0.008 | Cruiser, destroyer, combat support, summer |
| | POFCAS | 1.5 | 1.0, 2.3 | 0.06 | |
| Heat/cold injury | Amphibious | 3.4 | 1.2, 9.7 | 0.02 | Cruiser, combat support |
| | Destroyer | 2.7 | 0.9, 8.6 | 0.09 | |
| | Summer | 15.7 | 5.1, 48.6 | <0.0001 | |
| Injury, working | Cruiser | 0.6 | 0.4, 1.0 | 0.04 | Amphibious, destroyer |
| | Combat support | 1.3 | 1.0, 1.8 | 0.06 | |
| Ophthalmologic | POFCAS | 1.2 | 1.0, 1.4 | 0.06 | Amphibious, cruiser, destroyer, combat support |
| Mental health | Amphibious | 0.2 | 0.1, 0.6 | 0.003 | POFCAS |
| | Cruiser | 0.3 | 0.2, 0.5 | <0.0001 | |
| | Destroyer | 0.3 | 0.1, 0.7 | 0.003 | |
| | Combat support | 0.2 | 0.1, 1.0 | 0.05 | |
| Combat/operational stress | Amphibious | 0.1 | 0.0, 0.9 | 0.04 | Destroyer, combat support |
| | Cruiser | 0.1 | 0.0, 1.4 | 0.09 | |
| | POFCAS | 0.4 | 0.1, 1.0 | 0.05 | |
| Other psychiatric disorders | Amphibious | 0.2 | 0.1, 0.6 | 0.005 | |
| | Cruiser | 0.3 | 0.2, 0.7 | 0.003 | |
| | Destroyer | 0.3 | 0.1, 0.8 | 0.01 | |
| | Combat support | 0.2 | 0.0, 0.8 | 0.03 | |
| | POFCAS | 1.4 | 1.0, 2.0 | 0.05 | |
| Respiratory | Destroyer | 1.6 | 1.1, 2.2 | 0.015 | Amphibious, cruiser |
| | Combat support | 2.0 | 1.6, 2.6 | <0.0001 | |
| | Summer | 0.6 | 0.4, 0.9 | 0.007 | |
| Sexual transmitted disease | Destroyer | 0.4 | 0.1, 1.3 | 0.14 | Amphibious, cruiser |
| | Combat support | 2.2 | 0.8, 6.2 | 0.13 | |
| | Summer | 2.0 | 0.9, 4.8 | 0.10 | |
| | POFCAS | 1.4 | 0.9, 2.2 | 0.15 | |
| Fever, unexplained | Summer | 2.2 | 0.8, 6.3 | 0.15 | POFCAS |

[a] Baseline = rate for carrier (large ship) in winter season adjusted for all the other significant variables found in bivariate analysis.

[b] POFCAS, modeled as ordinal variable.

associated initial visits were 70 to 80% lower for all ship classes compared with aircraft carriers. Decreased rates of combat/operational stress initial visits were associated with increases in POFCAS (IRR, 0.4; $p = 0.05$). However, increased rates of other psychiatric initial visits were associated with increases in POFCAS (IRR, 1.4; $p = 0.05$).

Summer season was associated with a decrease in respiratory disease rates (IRR, 0.6; $p = 0.007$), but an increase in heat/cold injury (IRR, 15.7; $p < 0.0001$). Unexplained fever (IRR, 2.2; $p = 0.15$) and sexually transmitted disease (IRR, 2.0; $p = 0.10$) initial visits tended to be higher in the summer as well. Destroyer and combat ship classes were associated with increased respiratory initial visit rates compared with carriers (IRR, 1.6; $p = 0.02$; IRR, 2.0; $p < 0.0001$, respectively). We found total DNBI initial visit rate, excluding gynecologic visits, was not associated with ship class, season, or POFCAS in the multivariate analysis.

With respect to morbidity outcomes, we found there were 4.4 SIQ days, 16 light duty days, 0.6 hospital admissions, and 1.5 hospital bed days per 1,000 person-weeks. Infectious GI, gynecologic, and other medical/surgical problems were the top three DNBI categories resulting in days of SIQ to be given (Table VI). Working injury, dermatologic, and other medical/surgical problems were the top three DNBI categories for which days of light duty were given. Hospital admission rates were relatively low compared with initial visit rates, with dermatologic, psychiatric, and other medical/surgical admissions accounting for the top three. There were no hospital admissions for gynecologic, heat/cold injury, recreational injury, motor vehicle injury, or sexually transmitted disease.

On average, 12 days of SIQ were given for every 100 DNBI initial visits (Table VII). Motor vehicle injury, unexplained fevers, and infectious GI illnesses were the categories receiving the largest number of SIQ days per 100 initial visits. Forty-two days of light duty were given for every 100 initial DNBI initial visits for all categories. Working, recreational, and motor vehicle injury admissions each had on average one or more days of light duty given per visit. Only 1% of total DNBI initial visits were admitted to the ships' hospital. Combat/operational stress, psychiatric, and unexplained fever had the highest case admission rates of 5 admissions per 100 DNBI initial visits. The mean length of stay for a hospital

TABLE VI

DAYS OF SIQ, LIGHT DUTY, HOSPITAL ADMISSIONS, AND BED DAY RATES BY DNBI CATEGORY

| | DNBI Rate (*n*/1,000 person-weeks) | | | |
|---|---|---|---|---|
| DNBI Category | SIQ Days | Light Duty Days | Hospital Admissions | Bed Days |
| Dermatologic | 0.3 | 1.7 | 0.1 | 0.3 |
| GI, infectious | 1.3 | 0.4 | 0.01 | 0.04 |
| Gynecologic | 0.9 | 1.5 | 0 | 0 |
| Heat/cold injury | 0.1 | 0.08 | 0 | 0 |
| Injury, total | 0.6 | 9.0 | 0.11 | 0.4 |
| Recreational | 0.09 | 1.5 | 0 | 0 |
| Motor vehicle | 0.004 | 0.02 | 0 | 0 |
| Working | 0.4 | 6.4 | 0.04 | 0.2 |
| Other | 0.1 | 1.1 | 0.06 | 0.2 |
| Ophthalmologic | 0.1 | 0.1 | 0.01 | 0.004 |
| Mental health | 0.07 | 0.2 | 0.1 | 0.4 |
| Combat/operational stress | 0.05 | 0.08 | 0.01 | 0.06 |
| Other psychiatric disorders | 0.02 | 0.1 | 0.09 | 0.3 |
| Respiratory | 0.6 | 0.5 | 0.03 | 0.08 |
| Sexually transmitted disease | 0.003 | 0 | 0 | 0 |
| Fever, unexplained | 0.02 | 0.005 | 0.04 | 0 |
| All other, medical/surgical | 1.2 | 4 | 0.3 | 0.9 |
| Total DNBI | 4.4 | 16.3 | 0.6 | 1.5 |

TABLE VII

SI OF SIQ DAYS, LIGHT DUTY DAYS, HOSPITAL ADMISSIONS, AND BED DAYS FOR DNBI CATEGORIES

| | SI = Days or Admissions/100 Initial Visits of Category | | | |
|---|---|---|---|---|
| DNBI Category | SIQ Days | Light Duty Days | Hospital Admissions | Bed Days[a] |
| Dermatologic | 3 | 22 | 1 | 3 |
| GI, infectious | 41 | 11 | 1 | 3 |
| Gynecologic | 5 | 12 | 0 | NA[b] |
| Heat/cold injury | 27 | 15 | 0 | NA |
| Injury, total | 9 | 143 | 1 | 4 |
| Recreational | 8 | 141 | 0 | NA |
| Motor vehicle | 112 | 100 | 0 | NA |
| Working | 9 | 163 | 1 | 4 |
| Other | 10 | 83 | 4 | 3 |
| Ophthalmologic | 8 | 11 | 1 | 1 |
| Mental health | 4 | 9 | 5 | 4 |
| Combat/operational stress | 18 | 33 | 5 | 5 |
| Other psychiatric disorders | 2 | 5 | 5 | 4 |
| Respiratory | 13 | 11 | 1 | 2 |
| Sexually transmitted disease | 2 | 0 | 0 | NA |
| Fever, unexplained | 56 | 11 | 5 | 2 |
| All other, medical/surgical | 10 | 38 | 3 | 3 |
| Total DNBI | 12 | 42 | 1 | 3 |

[a] Bed days = number of bed days per hospital admission.
[b] NA, No admissions.

admission was 3 days. Combat/operational stress, working injury, and psychiatric admissions were found to have the longest mean bed days per admission.

## Discussion

In this study, we found significant differences in DNBI rates from JCS referent rates among and between the different U.S. Navy ships while forward deployed. Although the total DNBI rate for all ship types combined was similar to the JCS referent rate, there were a number of significant differences between the categorical DNBI rates and those suggested by the JCS. Specifically, we found rates of dermatologic, gynecologic, ophthalmologic, and respiratory illness significantly higher than the corresponding JCS referent rates, whereas initial visit rates of infectious GI disease, all categories of injury, heat/cold injury, combat/operational stress, and sexually transmitted diseases were significantly lower. Respiratory disease is a known problem among shipboard personnel given the high density of personnel and close quarters. Furthermore, our finding of high shipboard dermatologic rates is consistent with others studies.[6,12] The finding of higher than expected ophthalmologic rates is interesting and of uncertain etiology. Factors inherently related to shipboard disease and injury risk factors and factors that are related to the development of the JCS referent rates may explain these disparities. Based on the differences we have found specific to the shipboard community, it might be feasible to develop service- and platform-specific DNBI rate parameters that could be used to better measure the "vital signs" of the individual unit operational platforms, consistent with JCS guidelines.[16]

In addition, we found a number of differences between our rates and those reported by Bohnker et al.[2] in the original study, with which our data partially overlap. These differences are likely attributable to the different methods of rate calculation and our analysis of data from additional observation time. Bohnker et al. calculated mean DNBI rates based on the rates reported from each unit. This method of calculation gives each unit the same computational weight, regardless of the ship size. The estimates derived by this method may be biased. Our method estimated rates based on the event counts and the ship strength of each reporting unit. Differences between the rates of the two reported studies could also be from the additional data from a longer observation period that we used for analysis. It is possible that disease outbreaks or changes in operational tempo might have affected the rate estimates between the two studies. An additional year of data analysis would likely add even more precision to the estimates. Last, because of the count nature of the data, Poisson regression or, in this case, negative binomial model is the most appropriate statistical method to produce unbiased estimates of DNBI rates.

We found a number of differences in total and categorical DNBI rates among ship types. In general, total DNBI rates were higher on larger and medium-sized platforms compared with smaller platforms. This finding was surprising given the opposite finding of the three previously published studies, which described DNBI and its relation to ship size.[3,5,6] This discordance of results could possibly be related to secular changes in the shipboard DNBI risk, given that these three studies were based on analysis of data from the 1970s and, furthermore, that these studies used a different DNBI surveillance method for obtaining data. Other factors such as differential reporting, occupational hazards, and port visits among the ship class could also explain some of the variability.

Categorical DNBI rates were found to be quite different between the different ship types, even after adjusting for POFCAS. Specifically, lower rates of dermatologic disease on small platforms conflicts with previous studies.[3,6] The explanation of this discordance remains a mystery but may include implementation of programs to prevent occupational dermatologic illness (e.g., irritant/contact dermatitis) in response to previous studies that found higher rates of dermatologic disease; however, we are not aware of the implementation of any such program. Carriers and amphibious assault ships tended to have higher rates of infectious GI visits compared with other ship classes. This finding could be related to the length of liberty for port visits. An additional finding is that mental health initial visits are much higher on aircraft carriers compared with other ship classes, perhaps attributable to the more stressful nature of life aboard this class of ship. Furthermore, we found that injury was significantly higher in the medium-sized ship classes (amphibious assault/combat support) compared with larger and smaller classes and may be related to occupational risk factors specific to these ship classes. One previous study found a higher rate of injury on smaller class ships compared with other ship classes.[3]

There was a positive association with seasonality and respiratory illness, other medical/surgical, and sexually transmitted diseases. Summer season saw an increase in sexually transmitted diseases, possibly explained by changes in port-call durations and frequencies. Conversely, during the winter, a significant increase in respiratory illness and other medical/surgical initial visits was noted. Our reported respiratory illness rates are in agreement with published reports that show an increase in respiratory disease during cooler months.[18]

The presence of confounding was suspected given the differential relationship between POFCAS within and among classes of ship. Multivariate analysis, adjusting for ship class, revealed that increasing POFCAS was positively associated with psychiatric illness, but was negatively associated with combat/operational stress medical visits. And although losing statistical significance, increasing POFCAS tended toward an association with increases of initial visits rates from infectious GI, gynecologic, and ophthalmologic illnesses after adjusting for ship class.

These analyses suggest that something unique among women may explain the differential rates of medical visits based on gender and is consistent with previous DNBI literature.[8,9] In addition, published studies among civilian populations indicate that women use more health care services than do men.[19] However, the context of aggregate events in data our data places interpretation at risk of bias from ecological fallacy.

Equally as important as initial visit incidence is morbidity associated with DNBI. Nearly 30% of all SIQ days were from infectious GI illnesses. All other medical/surgical (27%) and gynecologic illnesses (20%) accounted for a relatively higher number of days lost because of SIQ. These data suggest that efforts to reduce the incidence or to minimize the morbidity would likely have a significant impact on reducing the burden of lost person-days.

The overall rate of light duty days given was nearly four times higher than SIQ days (16.3 vs. 4.4 per 1,000 person-weeks). The equivalence between these two morbidity outcomes and the shipboard impact is uncertain, but is an important consideration for prioritizing the impact of individual DNBI categories. The relative proportion of individual DNBI categories accounting for light duty days was highest for working injury (39%), with dermatologic, gynecologic, and recreational injury accounting for approximately 10% each. Within the injury category, it appears that working injuries (16.3 days per 10 initial visits) are given more light duty days compared with the other injury categories. This finding is not surprising given the rigorous and dangerous demands of military service and needs to remain a top priority of force health protection.

An SI was computed to explore the relative morbidity associated with each DNBI category. Across all categories, motor vehicle injury accounted for the most days of SIQ given per injury related visit, followed by fever of unexplained origin and infectious GI illness. Interestingly, other categories of injury were not responsible for as many SIQ days given, which is probably explained by the temporary incapacity associated with motor vehicle injuries and the safety of vehicles and restraining devices. Also of note is that these estimates were obtained from only a few ($n$ = 3) motor vehicle accidents reported and results should thus be interpreted cautiously.

Overall, hospital admission rates were low, with 6 admissions for every 10,000 person-weeks. Other medical/surgical (50%), injuries combined (18%), dermatologic (17%), and other psychiatric illness (15%) accounted for the highest proportions of these admissions. Previous studies have found that mental disorders, infectious GI illnesses, accidents, poisonings, and violence accounted for the largest proportion of shipboard hospital admissions.[11]

What accounts for visits and hospitalizations associated with other medical/surgical category is uncertain. However, given that this category accounts for 26% of total DNBI initial visits, 27% of SIQ days, 25% of light duty days, and 50% of hospital admissions, further investigation is warranted.

One limitation of this study was that data were collected from ships in a single operational theater, the Middle East region. Other studies have shown that the operational theater impacts reported DNBI rates.[3,7,17] Another limitation was that the surveillance period covered peace-time conditions (ending just before the events of September 11). Previous studies report significant differences in DNBI rates (generally lower) during war time compared with peace time.[5,6,20] Another possible limitation was the limited surveillance period of our data, analyzing a single year of data. There are many factors, including operational history and recent disease prevention/health promotion interventions, that may change disease and injury rates during any given year.

This study assessed the health status of operational shipboard forces from weekly DNBI surveillance data. We were able to compare DNBI rates across multiple ship classes, controlling for several putative confounding factors, with established JCS referent rates used for interventional purposes. The significant divergence of our results with the JCS referent rates may indicate a need for ship class adjustment. However, additional studies must be conducted to confirm our findings and recommendations, as well as to elucidate other factors that may lead to significant bias among different ship classes. Furthermore, the largest individual DNBI category initial visit rate was other/medical surgical, suggesting that additional studies need to be conducted to describe this "catch-all" category.

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