Suicide and Life-Threatening Behavior 36(2) April 2006
© 2006 The American Association of Suicidology

Strengthening the Validity of Population-Based Suicide Rate Comparisons: An Illustration Using U.S. Military and Civilian Data

Karen M. Eaton, MS, Stephen C. Messer, PhD, Abigail L. Garvey Wilson, MPH, and Charles W. Hoge, MD

The objectives of this study were to generate precise estimates of suicide rates in the military while controlling for factors contributing to rate variability such as demographic differences and classification bias, and to develop a simple methodology for the determination of statistically derived thresholds for detecting significant rate changes. Suicide rate estimates were calculated for the military population and each service branch over 11 years, directly standardized to the 2000 U.S. population. Military rates were highly comparable across branches and were approximately 20% lower than the civilian rate. Direct adjustment essentially controlled for the demographic confounds in this sample. Applying the Poisson-based method, we demonstrate that suicide rate fluctuations as large as 20–40% in any year may be attributed to random error.

Suicide remains a major health problem in the United States despite increased knowledge of risk factors, growing public awareness, and calls for national prevention efforts. According to the National Strategy for Suicide Prevention in 2000, suicide was the eleventh leading cause of death in the United States, and the third leading cause of death among young people between the ages of 10 and 24, as well as the second leading cause of death for people between the ages of 25 and 34 (Centers for Disease Control and Prevention [CDC], 2005). Over the past five decades, suicide rates have nearly tripled among adolescents and young adults, a pattern purportedly linked to increased prevalence of mood disorders, nuclear family dissolution, and firearm access (U.S. Public Health Service, 1999).

These findings, in concert with growing public interest, are influencing health policy. For example, a major aim of public health programs such as Healthy People 2010 (U.S. Department of Health and Human Services, 2000) is to set goals for improving the nation's health. One of the Healthy People 2010 objectives is to reduce the national suicide rate by nearly 60 percent, from 11.3 to 5.0 per 100,000. Such objectives challenge public health practitioners, prevention scientists, and methodologists striving to dem-

Karen Eaton, Stephen Messer, and Charles Hoge are with the Division of Psychiatry and Neuroscience, Department of Military Psychiatry at Walter Reed Army Institute of Research; Abigail Garvey Wilson is with the Army Medical Surveillance Activity, U.S. Army Center for Health Promotion and Preventive Medicine.

This paper represents the personal views of the authors and does not represent the official position of the U.S. Army, Department of Defense, or the institutional affiliations noted.

Address correspondence to Karen Eaton, MS, Division of Neuroscience, Department of Psychiatry and Behavioral Sciences, Walter Reed Army Institute of Research, Room 2W94, 503 Robert Grant Avenue, Silver Spring, MD 20910; E-mail: Karen.eaton@na.amedd.army.mil

onstrate valid change in suicide rates over time and/or across populations.

Efforts to detect population-based suicide rate differences confront an array of validity threats. First, suicides are low frequency events. Even in larger populations, small differences in the number of self-inflicted deaths over time, or between groups over a single time interval, can result in wide fluctuations in rates. Second, differences in suicide rates between groups may be due to confounding population characteristics, such as differential demographic distributions. Ignoring such population patterns may result in misleading rates, particularly when comparing heterogeneous populations. Third, classification bias in the assignment of suicide as the manner of death may also result in imprecise and/or inaccurate rates. For example, the systematic misclassification of suicides as "accidents," as deaths with an "undetermined" manner or those in a "pending" determination status, will lead to an under-detection of suicides (Carr et al., 2004). Studies of suicide determinations demonstrate the magnitude of misclassification is substantial, with 20–30% of suicides inaccurately assigned as accidental or undetermined (Brent, Perper, & Allman, 1987; Kleck, 1988; Mohler & Earls, 2001; O'Carroll, 1989; Phillips & Ruth, 1993). Finally, the completeness of mortality reporting may be inconsistent over time and there may be long delays in completing the manner of death investigations. Both reporting errors and delays will contribute to a reduction of precision and accuracy in the estimation of suicide rates.

Methodological and validity issues become even more salient in studies of population groups. For example, the U.S. military has been the focus of a number of studies of prevalence and risk for suicide and suicidal behaviors dating back to the 1950s (Cassimatis & Rothberg, 1997; Datel & Johnson, 1979; Datel & Jones, 1982; Datel, Jones, & Esposito, 1981; Eggertsen & Goldstein, 1968; Hourani, Warrack, & Coben, 1999; Rock, 1988; Rothberg, Bartone, Holloway, & Marlowe, 1990; Rothberg, Fagan, & Shaw, 1990; Rothberg & Jones, 1987; Rothberg & McDowell, 1988; Rothberg, Rock, & Jones, 1984; Rothberg, Rock, Shaw, & Jones, 1988; Rothberg, Ursano, & Holloway, 1987). The military represents an excellent population for research due to the large population denominator and extensive demographic, morbidity, health care, and mortality databases; however, methodological limitations in military investigations have made it difficult to generate reliable and valid suicide rate estimates, to characterize and model trends and differences in suicide within and between service branches, and to assess the effectiveness of suicide prevention programs. Fluctuations in suicide rates in individual service branches (e.g., up to 40% over the past decade) make it difficult to link rate changes to any specific prevention efforts (Helmkamp, 1995). In fact, only one study to date has assessed the effectiveness of a military suicide prevention program (Knox, Litts, Talcott, Feig, & Caine, 2003). Additionally, from a policy perspective, apparent spikes in suicide rates often lead to heightened concerns among Department of Defense (DoD) leadership, and occasionally prompt intense public scrutiny (e.g., suicides among U.S. soldiers deployed to Iraq).

The U.S. active duty military represents an important segment of the adult population, as well as a valuable resource for conducting research. Comprised predominantly of young adults with a broad range of racial/ethnic diversity, the military population is primarily male (85 percent) with approximately half of the population between the ages of 17 to 26, a demographic profile at high risk for suicide. In contrast, military service members benefit from full-time employment and access to comprehensive health care, factors which may buffer suicide risk. In recent years, studies of the general health of soldiers have revealed substantial improvements. Practices such as intensive immunization/vaccination programs and injury prevention initiatives have enhanced the health of the military population (Peake, 2000; Powell, Fingerhut, Branche, & Perrotta, 2000; Sentell, Lacroix, Sentell, & Finstuen, 1997). Yet, despite decreases in overall mortality due to

illness, accidents, and homicide, suicide rates in the military have generally not shown comparable reductions, even with the implementation of suicide prevention programs. In fact, over the past decade, suicide continues to be the second or third leading cause of death among active duty military personnel (Directorate for Information Operations and Reports, 2003; Helmkamp, 1996; Rothberg et al., 1987).

The current study has four primary objectives: (1) to illustrate the computation of directly adjusted suicide rates for the total military population, for comparison with the civilian population; (2) to utilize the directly standardized rates to make accurate comparisons across service branches; (3) to estimate and account for validity threats, measurement error, and other factors that influence suicide rate estimates; and (4) to demonstrate a statistically-driven methodology for the determination of significant suicide rate deviations from an expected value. Our overarching aim is to provide public health practitioners with basic knowledge and simple tools to facilitate decision making and to strengthen suicide surveillance, monitoring, and prevention efforts.

MATERIALS AND METHODS

Military Population

Data. The current study analyzed data from active duty service members in the U.S. military (Army, Air Force, Navy, Marine Corps) between the years 1990 through 2000. The study population consisted of all active duty personnel between the ages of 17 to 64, both enlisted as well as officers (17,696,802 total person-years). Mortality and denominator data for the 11-year period was obtained through the Defense Medical Surveillance System (DMSS; Rubertone & Brundage, 2002). The DMSS contains current and comprehensive population-based data on all hospitalizations; ambulatory visits; reportable medical events; and demographic, deployment, and occupational data for the active duty population, currently 1.3 million service members strong (Hoge et al., 2002). DMSS mortality data are input via the DoD Directorate for Information and Operations Reports (DIOR) system, which receives information from the casualty reporting offices of each service branch. DMSS defines *suicides* as deaths receiving codes of E950 through E959 from the *International Classification of Diseases, Volume 9* (World Health Organization, 1977) and codes of X-60 through X-84 and Y87 from the *International Classification of Diseases, Volume 10* (World Health Organization, 1992). DMSS recorded 2,091 suicides in the military population over the study period.

Civilian Population

Data. The Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control, National Center for Health Statistics, Vital Health Statistics System was the source for the civilian population mortality data, extracted from the Web-based Injury Statistics Query and Reporting System (WISQARS; CDC, 2003). The 2000 U.S. Census provided the civilian demographic and denominator information. We included civilians 15 and 16 years old due to the Census manner of age stratification. A total of 190,458,952 constituted the civilian study population. CDC reported 23,450 suicides during 2000.

Analysis

To control for distributional differences across populations, we applied the method of direct adjustment to standardize suicide rates in the military population, over the 11-year period, to the 2000 civilian population (Kleinbaum, Kupper, & Morgenstern, 1982). Rates generated using direct standardization are interpreted as those that would be obtained if the study population(s) had a distribution identical to that of the standard population on the selected demographic variables. For the adjusted suicide rate comparison across the total military and civilian populations, as well as for the contrasts across military ser-

vice branches, we pooled 11 years (1990–2000) of military data, which allowed for more precision, while concurrently yielding more stable rates through the averaging of the yearly rate fluctuations. Using the civilian population as the reference group, the military suicide rates were adjusted by gender, age, and race/ethnicity. We combined all non-White race/ethnicity categories (African American, Hispanic, American Indian/Alaskan Native, Asian/Pacific Islander, etc.) to have sufficient numbers of observations in most cells.

To address potential classification bias in the military data, we computed two sets of adjusted suicide rates. One set of rates, the liberal/higher estimate, included confirmed suicides as well as all pending and undetermined deaths, while the conservative/lower estimate included only confirmed suicides. The Vital Health Statistics System, our source for civilian death rates, does not utilize a pending category for manner of death, therefore we computed a liberal crude rate for civilians, which comprised confirmed suicides and undetermined deaths. In the military, deaths pending final manner of death determination, or deaths classified as undetermined, frequently involve suspicious circumstances such as falls, overdoses, or drowning, where there is uncertainty regarding suicidal intent. Several studies demonstrate the importance of including pending/undetermined classifications in examinations of the prevalence of suicide (Brent et al., 1987; Fear & Williamson, 2003; Sainsbury & Jenkins, 1982).

As noted, suicide is a rare event; therefore, it is critical that researchers apply statistical techniques that ensure an appropriate level of precision, which maximizes the accuracy or validity of inferences regarding population rate differences. We conceptualized suicide counts as a Poisson random variable, thus the computation of 95% confidence intervals (CI) relied on the normal approximation to the Poisson ($95\%\ \mathrm{CI} = r \pm 1.96 \times (r \sqrt{x})$; where r = rate, x = suicide count; valid where $x < 100$) (Chaing, 1961; Fisher & van Belle, 1993; Keyfitz, 1966).

Lastly, we provide a general statistical method to facilitate decision making for the scenario in which a determination is required as to whether an observed suicide rate exceeds some expected value. This strategy is intended to enhance valid inferences concerning significant suicide rate deviations from some expected value, an issue confronted by prevention program and policy analysts. We demonstrate this by showing the computation of the expected suicide count for a population (service branch) at current size and baseline period using the observed suicide rate.

First, we computed an expected baseline value. Most simply, an arithmetic mean or median can be calculated over the 11-year period; however, this measure of central tendency is biased to the extent that there are significant deviations from the mean over time. To address this concern, we estimated the extent of departures from a mean value by modeling linear or polynomial regressions, and detecting significant deviations from the best fitting model for any year. This was done by inspecting the studentized residuals and identifying any that demonstrated statistical significance at $\alpha < 0.05$ (a studentized residual value $>\pm 2.0$). If we observed significant residuals, we deleted them before computing the mean. If we failed to detect any significant residuals, then we computed the mean as an unbiased estimate of the expected value.

After calculating the expected value for the rate, we determined the expected value for the count/number of suicides in each of the service branches by multiplying the rate by the population size. Having the expected count of suicides, we then determined the Poisson probability at which a significant difference in the observed and expected suicide counts existed. We used CDC's public domain software package, EPI INFO 6.0 (available on-line at http://www.cdc.gov/epiinfo) to identify the observed count that would result in $p < 0.05$, indicating a significant difference from the expected. By applying the Poisson standard versus observed test, we were able to determine what observed value was necessary to achieve a significant expected versus observed difference in suicide counts for a given year. For manual computations,

Pr $(X = x) = e^{-\lambda} \times \lambda^x / x!$; where x indicates integers 0 to X, with X as the observed count; e is the natural logarithm; λ is the expected count; and $x!$ is the factorial of x (Woolson & Clarke, 2002).

RESULTS

Suicide in the Military and Civilian Populations: Directly Adjusted Rates

Inspection of Table 1 reveals substantial differences in the demographic distributions of the military and civilian populations. For example, the military is composed of proportionately more males and younger adults, but there was little difference across populations in the proportion of non-Whites, with only a slightly larger representation in the military. There were some notable demographic differences between the military services. Taken as a whole, these differences in demographic profiles are very likely to bias simple (crude/unadjusted) suicide rate comparisons between populations, given that demographic variables strongly relate to suicide.

A basic step in the computation of adjusted suicide rates is the enumeration of suicide events with their respective population group denominators, broken out by the demographic variables of interest. An initial check of this stratification (by age, gender, and race/ethnicity) highlighted particular population risk groups, within and across the military and civilian populations, and revealed some comparability in the patterning of suicide risk by demographics. Applying the method of direct standardization for age/gender/race simultaneously, we adjusted for these demographic differences, while using the civilian population as the reference group, providing valid population rate comparisons (Table 2). The overall conservative suicide rate in the civilian population in the year 2000 is 12.31 suicides/100,000/year. Comparing the civilian rate with the unadjusted military rate of 11.82/100,000 would lead to the biased conclusion that there are small population differences; however, applying di-

TABLE 1
Demographic Distributions of the Civilian (Standard) and Military (Study) Populations

Population	Civilian	Total Military	Army	Air Force	Navy	Marines
Denominator	190,458,952	17,696,802	6,125,143	4,599,832	5,006,794	1,965,033
% of Total	100	100	35.00	26.00	28.00	11.00
Demographics						
Gender						
% Male	49.80	87.50	86.90	84.10	88.60	95.00
% Female	50.20	12.50	13.10	15.90	11.40	5.00
Race						
White, Non-Hispanic	75.10	72.10	62.90	79.50	76.00	73.30
Non-White[1]	24.90	27.90	37.10	20.50	24.00	26.70
Age Group						
15–19	11.00	7.70	7.70	4.90	8.00	13.90
20–24	10.30	31.60	32.00	24.50	32.30	45.80
25–29	10.50	21.80	22.60	22.80	21.60	17.10
30–34	11.00	16.90	16.60	20.00	16.60	10.70
35–39	12.20	13.30	12.50	17.00	13.00	7.80
40–64	45.00	8.70	8.60	10.80	8.50	4.60

[1]Non-White includes African American, Hispanic, American Indian/Alaskan Native, Asian/Pacific Islander, etc.

TABLE 2
Civilian and Military Population Suicides: Crude and Directly Adjusted Rates

Population	Crude Rates, Conservative	95% CI	Adjusted Rates, Conservative	95% CI	Crude Rates, Liberal	95% CI	Adjusted Rates, Liberal	95% CI
Civilian	12.31	12.15, 12.47			14.15*	13.97, 14.33*		
Total Military	11.82	11.31, 12.33	8.31	7.95, 8.67	12.98	12.45, 13.51	9.16	8.79, 9.53
Army	12.36	11.48, 13.24	8.70	8.07, 9.33	12.91	12.01, 13.81	9.03	8.40, 9.66
Air Force	11.35	10.37, 12.33	9.13	8.35, 9.91	11.98	10.98, 12.98	9.59	8.79, 10.39
Navy	10.71	9.81, 11.61	6.50	5.95, 7.05	13.40	12.38, 14.42	9.45	8.72, 10.18
Marines	14.05	12.38, 15.72	8.87	7.83, 9.91	15.01	13.30, 16.72	9.48	8.40, 10.56

Note. Conservative rate = confirmed suicides. Liberal rate = confirmed suicides + pending + undetermined.

*Crude rates, Liberal-Civilians = confirmed suicides + undetermined only. No pending category exists for Civilian manners of death.

rect adjustment to the total military population reveals that rates in the military are significantly lower than among civilian (8.31 vs. 12.31/100,000/yr.). Lower rates among military personnel persisted using estimates based on either the conservative or liberal definitions (i.e., 33% and 25% lower in the military when compared to the conservative civilian crude rate, and 8% and 36% lower when compared to the liberal civilian crude rate).

Suicide Across the Service Branches: Adjusted Rate Comparisons

Table 2 provides a summary of the crude suicide rates, as well as the adjusted suicide rates, for the total military and the four service branches over the 11-year period. The crude suicide rates for the four branches ranged from 10.7 to 14.1/100,000/year. For each of the branches, the direct rate adjustment resulted in estimates that were substantially lower (6.5–9.1/100,000/yr.) than the crude rates. With the application of the liberal definition, the rates changed minimally for the Army, Air Force, and Marines, but the Navy exhibited a major change. The Navy rate became analogous to the other branches, resulting in directly adjusted rates for the four branches ranging from 9.0 to 9.6/100,000/year (compared to the conservative adjusted rate range of 6.5–9.1). Notably, among the 207 total deaths listed as pending or undetermined during the study period, 125 (60%) were from the Navy. This disproportionately large number of pending/undetermined deaths may be attributable to the method of death (i.e., falls from ships) where suicidal intent is difficult to ascertain (Helmkamp & Bone, 1986).

Detecting Significant Deviations from Baseline. Figure 1 shows suicide rates for each branch over the 11-year period. Fluctuations in rates are prominent, particularly for the Marine Corps. A question often posed to public health practitioners by those responsible for policy or programs is, "Does this year's rate differ from previous years?" Although the derivation of a number of tactics is possible, we propose and illustrate the use of the Poisson standard versus expected test (see methods for description).

If the expected number of suicides in the current year is assumed to be equal to the average yearly rate pooled over the 11-year period, then the expected number of suicides (at the current population size) is 59 for the Army, 41 for the Air Force, 37 for the Navy, and 24 for the Marines (see Table 3). Examining a range of potential observed counts given the expected value for each military subpopulation, we found the observed value that would meet the threshold for a significant expected/observed difference. The Pois-

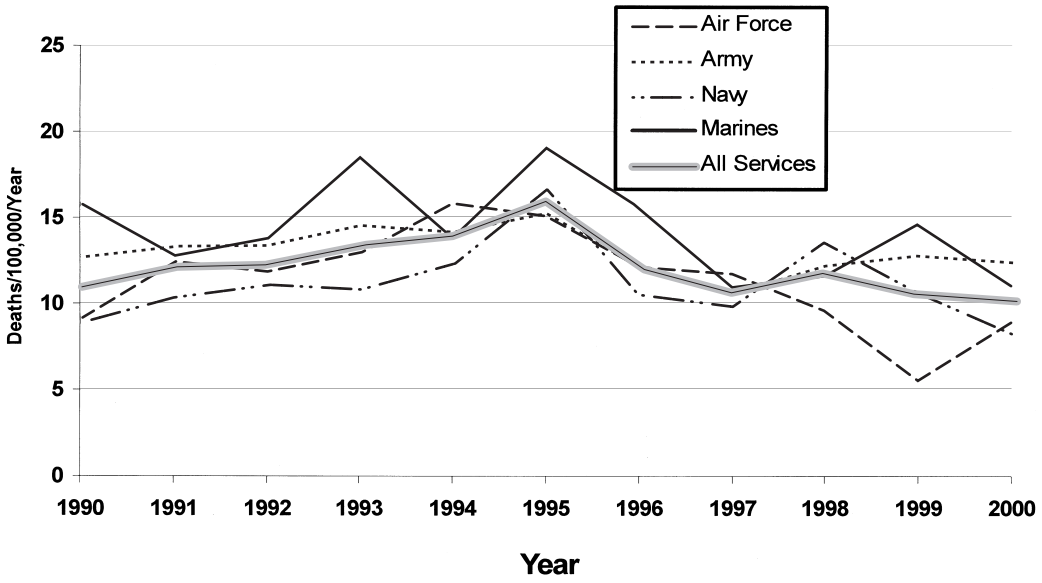

Figure 1. Department of Defense (DoD) suicide trends over 11 year study period (1990–2000).

son test indicated that for any given year and service branch, anywhere from a 24% to 38% suicide rate increase was required to meet the $p < .05$ significance level.

DISCUSSION

The purpose of this study was to illustrate methods for enhancing the validity of population-based comparisons of suicide rates. We demonstrated a basic strategy to account for factors, such as bias, confounding, and statistical error, which can distort the precision of suicide rate estimates. We illustrated methods to deal with these threats, including the computation of directly adjusted suicide rates, the utilization of the directly standardized rates in comparisons between populations and across service branches, and the computation of Poisson derived estimates of significant observed versus expected/baseline differences in suicide counts.

TABLE 3
Expected Suicide Rate Variability in the Military

Service	Current Population Size	Expected Conservative Suicide Rate Based on 1990–2000 Average	Expected # of Suicides at Current Population Size	Number (percent change) that has probability <0.05*
Army	480,000	12.36/100,000/year	59/year	73 (24)
Air Force	360,000	11.35/100,000/year	41/year	53 (29)
Navy	350,000	10.71/100,000/year	37/year	48 (30)
Marines	170,000	14.05/100,000/year	24/year	33 (38)

*This column shows threshold at which and above which the number of suicides are rare enough to have a probability of <0.05 compared with the expected number of suicides for any given year. Statistic based on Poisson equation rare event vs. standard.

Due to dramatic demographic differences (particularly by age and gender), the method of direct adjustment provided more accurate rates for comparison than contrasting crude suicide rates, both for the military and civilian populations, and for within service branch comparisons. Rates before adjustment suggested little difference in the incidence of suicide among military personnel and civilians (11.82 vs. 12.31/100,000/yr.); however, after adjustment and standardization, the total military rate was 33% and 25% lower (using the conservative and liberal definitions, respectively) than the civilian population.

Although there was a wide range of observed differences between military service branches in unadjusted rates over the 11-year period (i.e., 10.7–14.1/100,000/year), the range and magnitude of these differences were lowered after direct adjustment (6.5–9.1/100,000/yr.). This finding illustrates how comparisons of simple/crude suicide rates can mislead and suggests that the most important factor contributing to rate differences between service branch subpopulations is the differential distribution of demographic characteristics related to suicide incidence.

Given the similarity across the services in terms of enlistment requirements and procedures as well as classification of deaths, it seems reasonable that the rates across the four service branches would be very similar. However, due to the likelihood of classification bias in rates and the possibility of differential degrees of bias across populations, the lower conservative suicide rate in the Navy was informative. We observed a greater proportion of pending and undetermined death cases in the Navy than in the other service branches. Indeed, the inclusion of pending and undetermined deaths in the liberal estimate brought the adjusted Navy rate in line with rates observed in the other branches. This suggests that the majority of pending and undetermined deaths in the Navy may be suicides, and is consistent with previous research regarding the degree to which classification bias can affect suicide rate estimates. Unless there is substantial evidence, such as a suicide note or an eyewitness account, that a death was the result of an intentional self-inflicted injury, a classification of suicide may not be assigned (Lindqvist & Gustafsson, 2002). Further, it is estimated that the incidence of suicide may be underreported by at least 10% because of the stringent suicidal intent criterion (CDC, 1988). Several studies from civilian populations, based on careful analysis of death records by independent reviews, have estimated that 20–30% of suicides receive classifications of "other" manner of death (Brent et al., 1987; Carr et al., 2004; Kleck, 1988; Mohler & Earls, 2001; O'Carroll, 1989; Phillips & Ruth, 1993). These data suggest that suicide rate estimates need to account for the possibility of classification errors. When independent review of death records is not feasible, one viable approach is to use multiple definitions to increase measurement precision while reducing classification bias.

Over these 11 years of suicide surveillance, rates fluctuated widely in some service branches (e.g., 30–40% variability across years). With variation of this magnitude, the process of linking changes in rates to any specific prevention efforts is difficult. We demonstrated the application of a method to address the associated problems of substantial variance over time and rare events. Findings suggest that in the service branches, a 25–40% estimated versus observed difference (depending on the branch) was necessary to achieve significance at the 5% level. Public health practitioners, prevention specialists, and policy analysts can apply this method to create thresholds for the detection of nonrandom change in suicide rates, or other rare events, over time.

We note several limitations of the current study. First, the method of direct adjustment is a very useful tool for the calculation of an overall rate estimate; however, there are often constraints in the calculation of high precision adjusted rate estimates for some demographic groups. For example, in the current study non-White females represented such a small proportion of the total military population (11%) that in some of the cells of

the adjustment table, the counts were close or equal to zero. Therefore, some of the overall adjusted rates and confidence intervals are based on sparse cells. Our analyses focused on adjusted rates for the total military population (or its subpopulations) and not on finer-grained analyses, so our reported estimates are quite robust. Users should be wary of overinterpretation of the overall adjusted rate prior to an examination of stratum-specific rates. To the extent that populations exhibit different patterns in the specific rates, the overall directly adjusted rate provides a convenient summary, but may not accurately reflect important population differences. Additionally, using these methods, we were unable to determine the relative contribution of the different demographic factors on the differences in rates and were thus unable to determine which factors the rates were more sensitive to. Second, potential reporting and classification biases documented in other studies may have been operational in the current study. To address this concern, we only included deaths through the year 2000 to allow several years of follow-up to resolve pending death cases. Nonetheless, long delays in completing death investigations are a major impediment deserving attention for "real-time" suicide surveillance.

The method illustrated in this study provided increased precision and accuracy of suicide rate estimates and comparisons in the population of interest through the control of demographic differences, year-to-year variability in rare events, and classification bias. Our overarching aim was to provide public health practitioners and policy analysts with some basic knowledge and simple tools to facilitate decisionmaking, and to strengthen the precision and validity of suicide surveillance, monitoring, and prevention efforts.

REFERENCES

Brent, D. A., Perper, J. A., & Allman, C. J. (1987). Alcohol, firearms and suicide among youth: Temporal trends in Allegheny County, Pennsylvania, 1960 to 1983. *Journal of the American Medical Association*, *257*, 3369–3372.

Carr, J. R., Hoge, C. W., Niebuhr, D., Belenky, G., Potter, R., & Gardner, J. (2004). Suicide surveillance in the U.S. Military—Reporting and classification biases in rate calculations. *Suicide and Life-Threatening Behavior*, *34*, 233–242.

Cassimatis, E. G., & Rothberg, J. M. (1997). Suicide in the United States military. In A. J. Botsis, C. R. Soldatos, & C. N. Stefamos (Eds.), *Suicide: Biopsychosocial approaches* (pp. 23–32). Amsterdam: Elsevier Science.

Centers for Disease Control and Prevention. (1988). Current trends operational criteria for determining suicide. *Morbidity and Mortality Weekly Report*, *37*, 779–790.

Centers for Disease Control and Prevention. (2003). Web-based injury statistics query and reporting system (WISQARS) [On-line]. Retrieved July 2005 from www.cdc.gov/ncipc/wisqars.

Centers for Disease Control and Prevention. (2005). Web-based injury statistics query and reporting system (WISQARS) [On-line]. Retrieved July 21, 2005, from www.cdc.gov/ncipc/wisqars.

Chaing, C. L. (1961). Standard error of the age-adjusted rate. *Vital Statistics Special Reports*, *47*,9.

Datel, W. E., & Johnson, A. W. (1979). Suicide in United States Army personnel, 1975–1976. *Military Medicine*, *144*, 239–244.

Datel, W. E., & Jones, F. D. (1982). Suicide in United States Army personnel, 1979–1980. *Military Medicine*, *147*, 843–847.

Datel, W. E., Jones, F. D., & Esposito, M. E. (1981). Suicide in United States Army personnel, 1977–1978. *Military Medicine*, *146*, 387–392.

Directorate for Information Operations and Reports. (2003). U.S. active duty military deaths per 100,000 serving: 1980 through 2002. [On-line]. Retrieved January 2004 from http://web1.whs.osd.mil/mmid/casualty/Death_Rates1.pdf.

Eggertsen, P. F., & Goldstein, S. M. (1968). Suicide by Air Force personnel 1958 to 1964. *Military Medicine*, *133*, 26–32.

Fear, N. T., & Williamson, S. (2003). Suicide and open verdict deaths among males in the UK Regular Armed Forces. Ensleigh, Bath: Defence Analytical Services Agency.

Fisher, L. D., & van Belle, G. (1993). *Biostatistics: A methodology for the health sciences*. New York: Wiley.

Helmkamp, J. C. (1995). Suicides in the military: 1980–1992. *Military Medicine*, *160*, 45–50.

Helmkamp, J. C. (1996). Causes of death among U.S. military personnel: A 14 year summary, 1980–1993. *Military Medicine*, *161*, 311–317.

Helmkamp, J. C., & Bone, C. M. (1986).

Hospitalizations for accidents and injuries in the U.S. Navy: Environmental and occupational factors. *Journal of Occupational Medicine*, *28*, 269–275.

Hoge, C. W., Lesikar, S. E., Guevara, R., Lange, J., Brundage, J. F., Engel, C. C., et al. (2002). Mental disorders among U.S. military personnel in the 1990s: Association with high levels of health care utilization and early military attrition. *American Journal of Psychiatry*, *159*, 1576–1583.

Hourani, L. L., Warrack, A. G., & Coben, P. A. (1999). Suicide in the U.S. Marine Corps, 1990 to 1996. *Military Medicine*, *164*, 551–555.

Keyfitz, N. (1966). Sampling variance of standardized mortality rates. *Human Biology*, *38*, 309–317.

Kleck, G. (1988). Miscounting suicides. *Suicide and Life-Threatening Behavior*, *18*, 219–236.

Kleinbaum, D. G., Kupper, L. L., & Morgenstern, H. (1982). *Epidemiologic research: Principles and quantitative methods*. New York: Van Nostrand Reinhold.

Knox, K. L., Litts, D. A., Talcott, G. W., Feig, J. C., & Caine, E. D. (2003). Risk of suicide and related adverse outcomes after exposure to a suicide prevention programme in the US Air Force: Cohort study. *British Medical Journal*, *327*, 1376–1380.

Lindqvist, P., & Gustafsson, L. (2002). Suicide classification-clues and their use: A study of 122 cases of suicide and undetermined manner of death. *Forensic Science International*, *128*, 136–140.

Mohler, B., & Earls, F. (2001). Trends in adolescent suicide: Misclassification bias? *American Journal of Public Health*, *91*, 150–153.

O'Carroll, P. W. (1989). A consideration of the validity and reliability of suicide mortality data. *Suicide and Life-Threatening Behavior*, *19*, 1–16.

Peake, J. B. (2000). Reflections on injuries in the military. *American Journal of Preventive Medicine*, *18*, 4–5.

Phillips, D. P., & Ruth, T. E. (1993). Adequacy of official suicide statistics for scientific research and public policy. *Suicide and Life-Threatening Behavior*, *23*, 307–319.

Powell, K. E., Fingerhut, L. A., Branche, C. M., & Perrotta, D. M. (2000). Deaths due to injury in the military. *American Journal of Preventive Medicine*, *18*, 26–32.

Rock, N. L. (1988). Suicide and suicide attempts in the Army: A 10-year review. *Military Medicine*, *153*, 67–69.

Rothberg, J. M., Bartone, P. T., Holloway, H. C., & Marlowe, D. H. (1990). Life and death in the U.S. Army: In corpore sano. *Journal of the American Medical Association*, *264*, 2241–2244.

Rothberg, J. M., Fagan, J., & Shaw, J. (1990). Suicide in United States Army personnel, 1985–1986. *Military Medicine*, *155*, 452–456.

Rothberg, J. M., & Jones, F. D. (1987). Suicide in the U.S. Army: Epidemiological and periodic aspects. *Suicide and Life-Threatening Behavior*, *17*, 119–132.

Rothberg, J. M., & McDowell, C. P. (1988). Suicide in United States Air Force personnel, 1981–1985. *Military Medicine*, *153*, 645–648.

Rothberg, J. M., Rock, N. L., & Jones, F. D. (1984). Suicide in United States Army personnel, 1981–1982. *Military Medicine*, *149*, 537–541.

Rothberg, J. M., Rock, N. L., Shaw, J., & Jones, F. D. (1988). Suicide in United States Army personnel, 1983–1984. *Military Medicine*, *153*, 61–64.

Rothberg, J. M., Ursano, R. J., & Holloway, H. C. (1987). Suicide in the United States military. *Psychiatric Annals*, *17*, 545–548.

Rubertone, M. V., & Brundage, J. F. (2002). The Defense Medical Surveillance System and the Department of Defense Serum Repository: Glimpses of the future of public health surveillance. *American Journal of Public Health*, *92*, 1900–1904.

Sainsbury, P., & Jenkins, S. J. (1982). The accuracy of officially reported suicide statistics for purposes of epidemiological research. *Journal of Epidemiology and Community Health*, *36*, 43–48.

Sentell, J. W., Lacroix, M., Sentell, J. V., & Finstuen, K. (1997). Predictive patterns of suicidal behavior: The United States armed services versus the civilian population. *Military Medicine*, *168*, 168–171.

U.S. Department of Health and Human Services. (2000). *Healthy people 2010: Understanding and improving health* (2nd ed.). Washington, DC: U.S. Government Printing Office.

U.S. Public Health Service. (1999). *The surgeon general's call to action to prevent suicide*. Washington, DC.

Woolson, R. F., & Clarke, W. R. (2002). *Statistical methods for the analysis of biomedical data*. New York: Wiley-Interscience.

World Health Organization. (1977). *International classification of diseases, injuries, and causes of death. Ninth revision, Vols. I and II*. Geneva, Switzerland: Author.

World Health Organization. (1992). *International statistical classification of diseases and related health problems. Tenth revision*. Geneva, Switzerland: Author.

Manuscript Received: December 14, 2004
Revision Accepted: August 25, 2005