Adjusting Suicide Rates in a Military Population: Methods to Determine the Appropriate Standard Population

The choice of the standard population is important when calculating adjusted rates for a military population: results can influence policies and funding allocations for programs and initiatives for suicide prevention.

We describe the methodological considerations and decision-making process used in choosing a standard population for adjusting rates to compare suicide among US Army soldiers and the general US population. We examined 5 different standard populations, using the direct method to adjust annual suicide rates for the Army and the US population, 2004 to 2015, for age and for age and sex.


Information about the frequency of suicides in the US Army has been reported using a variety of measures,1–5 which can result in confusion, especially about how suicide in the Army compares to suicide in the US population. Adjustment of rates to a standard population allows comparison, but this may also be confusing because methods for and characteristics of adjustment often differ.6–8 We examined how different methods of calculation affect the story told about Army and US population suicide rates.

HISTORICAL BACKGROUND

From 1977 to 2003, the Army suicide rate was consistently lower than was the age- and sex-adjusted civilian suicide rate.9 However, for almost a decade, the Army has seen an increase in the number of deaths by suicide among soldiers.5,9 Death by suicide increased by 80% from 2004 to 2008 and surpassed the civilian rate in 2008.9 Since that time, the rate has continued to rise, peaking in 2012 and stabilizing in more recent years (2013–2015) as it approaches the civilian rate.5

In the mid-2000s, led by then vice chief of staff of the Army General Peter W. Chiarelli, senior leaders began to discuss, develop, and implement strategies to combat this rising public health issue. To do so effectively, information was needed to help frame the problem and substantiate the need for increased resources and program implementation. Therefore, in 2008, the office currently known as the Behavioral and Social Health Outcomes Practice (BSHOP) Division9 was created, in part to conduct routine surveillance and reporting of suicidal behavior data among soldiers.

Historically, at the organizational and strategic levels, suicide data have been reported in a variety of ways. Unpublished internal reports often consisted of count data, but this measure provided no context about whether the total number of soldiers at risk changed over time. Sometimes crude rates were reported, but there were concerns that the recommended methodology10 was not being employed accurately and that rates could not be replicated consistently.

Eventually, as recommended by the 2010 Department of Defense (DOD) Task Force Report on Suicide by Members of the Armed Forces,11 the Defense Suicide Prevention Office gathered subject matter experts from the DOD and created the Military Data and Surveillance Working Group (MDSWG). The MDSWG was tasked with revising the 2006 memorandum from the Under Secretary of Defense for Personnel and Readiness, which provided guidelines on suicide rate calculation methods.12 Conversation and collaboration indicated varying degrees of understanding among MDSWG members about (1) the complexity of suicide data; (2) the different types of rate calculations (crude, adjusted, stratum specific) and what they explain (e.g., the belief that crude rates from different populations could be compared directly in

ABOUT THE AUTHORS

a meaningful way); and (3) the importance of adjusting rates to inform comparisons. Over several months, the MDSWG rewrote DOD guidelines for crude suicide rate calculations and these were published in March 2014. Following publication of this guidance, the Defense Suicide Prevention Office became the official source of crude suicide rates for all branches of the US military.

Across the DOD, the principal source for suicide reporting is the annual DOD Suicide Event Report. This report includes crude and stratum-specific suicide rates for characteristics such as sex, rank, age, education, and marital status using the March 2014 guidelines; the 2015 report also includes adjusted rates. However, several military service organizations responsible for suicide surveillance do report adjusted rates using a variety of methods of adjustment. There is no published DOD guidance on a uniform method for adjusting military suicide rates.

When rates are compared across time or between populations, the populations being compared must be adjusted to a standard population, thereby accounting for differences in distribution by age as well as other characteristics. The choice of standard is particularly important in a military population because the military population is externally constrained (i.e., Congress sets the maximum size of the Army each year) unlike other, ever-increasing populations. Thus the distributions of age and sex in the Army tend to vary over time as a result of a number of factors such as changes in entrance and recruitment standards and waiver policies (e.g., waiver for failing to meet an existing recruiting or retention standard). Standardized rates can be strongly influenced by variations in the age and sex structure of the condition under investigation, even when population totals remain the same.

Therefore, the standard to which military rates are adjusted may need to be examined more often than do standards to which rates for other populations are adjusted. Using a consistent methodology for rate adjustment promotes effective communication among responsible authorities. Lack of guidance on suicide rate adjustment in the Army and military suggested the value of investigating the choice of a standard population.

Our objectives were to

1. Report on methodological considerations and the decision-making process used in choosing a standard population.
2. Illustrate the differences in adjusted Army and general US population suicide rates resulting from the use of several standard populations.
3. Discuss choosing a standard Army population to compare with the US population suicide rates and those of other military service branches.

Information from this investigation will benefit national, DOD, and Army leaders, public health professionals, Congress, and journalists, among others. It will assist in their understanding of the use of adjusted suicide rates in comparing patterns in the Army with those in the national US population and, in particular, the importance of the choice of a standard population in constructing adjusted rates.

CALCULATING RATES

Broadly, a rate measures the frequency with which an event occurs in a defined population over a specific period of time. A crude rate, the simplest and most straightforward type of rate, is calculated by dividing the total number of events (or cases, as pertaining to health-related events) by the total population at risk in the same period, multiplied by a factor of choice (e.g., 25 per 1000 or 2500 per 100 000 persons/soldiers). Although crude rates are a true measure of frequency, the comparison of crude rates between populations is misleading if their underlying characteristics differ. For example, crude rates for the US population and Army in 2006 were 14.3 and 17.8 per 100 000, respectively, suggesting that the suicide rate in the US population was lower than was the rate in the Army. To address this issue, statistical adjustment is applied to reduce or eliminate the confounding effects of characteristics, such as age and sex, which differ across populations or over time.

Adjusted rates account for the differences in characteristics between populations and ensure that any observed variations in the measured rates are not a result of the heterogeneity of the comparison populations. Continuing the example, when the 2006 US population and the 2006 Army population are adjusted for age and sex to the 2004 Army population distribution, the 2006 adjusted rate for the United States is 18.5 per 100 000, compared with 17.7 per 100 000 for the Army. This example illustrates that failure to adjust can result in misinterpretation of observed differences between the populations of interest.

The direct method of rate adjustment calculates rates for each group defined by the characteristics to be adjusted (e.g., men aged 17–24 years) and adjusts them by multiplying by the proportion of individuals in the standard population who have those same characteristics (Table A [available as a supplement to the online version of this article at http://www.ajph.org]). Adjusted rates are useful only for comparison with rates adjusted to the same standard. Moreover, unlike crude or stratum-specific rates, the values of the adjusted rates should not be taken as a measure of the disease or condition in the population but viewed only in relation to the comparison population as a measure of the difference between rates in the 2 populations.

INVESTIGATING THE STANDARDS

The Armed Forces Medical Examiner System, which investigates military deaths around the world, confirmed the Army suicide cases, which were Regular Army soldiers aged 17 to 64 years who died between 2004 and 2015 (n = 1382). We excluded National Guard and Army Reserve soldiers. The Defense Manpower Data Center provided Regular Army population data by age and sex.

We obtained confirmed US population suicide cases from the Multiple Cause of Death files in the Centers for Disease Control and Prevention’s Wide-ranging On-line Data for Epidemiologic Research database. This database also provided US population denominator data.

We drew the demographic characteristics of Army suicide cases from the Army Behavioral Health Integrated Data Environment, a comprehensive case registry of Army suicidal behaviors that includes information on demographic, military, and suicide event characteristics as well...
as medical, social, and criminal information. The original source for sex and date of birth was the Defense Manpower Data Center master personnel file. When demographic characteristics were missing from the personnel file (n = 17), we obtained sex from the Comprehensive Ambulatory Professional Encounter in the Military Health System Data Repository and date of birth from either the Comprehensive Ambulatory Professional Encounter Record or the Defense Casualty Information Processing System.

We calculated annual direct adjusted suicide rates (per 100,000 persons) for the Army and the US population using the following 5 methods (Tables B and C [available as a supplement to the online version of this article at http://www.ajph.org]):

1. **age adjustment:** 2000 US census population distribution
2. **age and sex adjustment:** 2000 US census population distribution
3. **age and sex adjustment:** 2004 Army population distribution
4. **age and sex adjustment:** 2015 Army population distribution
5. **age and sex adjustment:** Army population distribution for each year (e.g., in 2008, suicide rates in Army population and the US population were adjusted for age and sex to the distribution of the Army population in 2008)

The first method derives from a 1998 policy statement from the Department of Health and Human Services, which directed agencies to age-adjust mortality rates using the projected 2000 US population as the standard. The second method uses the same standard as the first but adjusts for age and sex. The third method is the standard BSHOP historically uses. We chose the fourth method to better reflect current Army population demographics. The fifth method investigates how controlling for changes in the distribution of sex and age over time would influence the standardized rates.

Over the study period, the crude US population suicide rates increased from 14.1 to 17.3 per 100,000, whereas the crude Army suicide rates ranged from a low of 10.8 per 100,000 in 2004 to a high of 30.1 per 100,000 in 2012 (Table 1). The US population suicide rates adjusted to the 2000 US population distribution were nearly identical to the crude US population suicide rate, whereas US population suicide rates adjusted to Army population distributions exceeded the crude US population suicide rates.

After adjustment for both age and sex to the 2000 US population distribution, the Army suicide rates fell below the US population rate in 8 of the 12 years reported. By contrast, after adjustment for age and sex using any of the Army population distributions (2004, 2015, or by year) as the standard population, the suicide rates in the Army were lower than were the US population suicide rates from 2004 to 2007 and higher from 2008 to 2015 (Figure 1). The shape of the Army age- and sex-adjusted rates was consistent with their respective crude rates when adjusted to any of the Army population distributions. Notably, the Army suicide rate decreased from the 2012 peak and is approaching the age- and sex-adjusted US population rate. Moreover, the current Army suicide rate is far from its low of 10.8 per 100,000 (2004 and earlier).

When adjusted to the 2000 US population distribution by age only, the Army suicide rates were lower than were the US suicide rates in 2004, 2005, and 2010. Moreover, when using this standard, adjusted Army suicide rates were lower than were the crude Army suicide rates in 10 of the 12 years reported. The biggest difference between crude and adjusted rates in the Army occurred in 2010 and 2012 (11.1 points). Overall, the lowest suicide rates for both the Army and US population were those age-adjusted to the 2000 US population distribution (Figure 2). However, the difference between crude and adjusted rates in the Army was much greater when adjusting to the US population distributions.

On the basis of this information and the use of a decision tree, we selected the 2015 Army population distribution to serve as the new standard in future BSHOP reporting. The decision tree (Figure 3), which we developed using epidemiological methodology, the literature, and group consensus, facilitated the thought process for determining an appropriate standard to use in the Army population.

We posed questions and, when appropriate, coupled them with recommendations and considerations related to the calculation of rates.

**CHOICE OF STANDARD, CHOICE OF STORY**

Army senior leaders often ask how Army suicide rates compare with suicide rates in the general US population. Although trends in Army rates over time are more important to the Army than are differences relative to US population rates, it is important to provide leaders with sound data because they engage with the public and other external audiences for whom the comparison is salient. Several factors and methodological considerations can greatly influence the results and the “story” the data tell. The adjusted rate calculations from this study illustrate this point.

What story do these results tell? When Army and US population suicide rates are standardized to the 2000 US population and adjusted for only age, there is a perceived difference (decrease in value) between the crude and adjusted Army rates. Although the adjusted rate has no intrinsic value, explaining this perceived difference to stakeholders can be challenging when the adjusted rate value appears to be lower (better) than a crude rate. Because of the sensitivity of the topic (suicide in the Army), selecting a standard population that produces numbers that are close to the crude rate is paramount. Ideally, the standard population selected should not minimize the rate (i.e., suggest that there is no problem), nor should it maximize the rate (suggesting the need for additional resources). Standardizing the Army and US population suicide rates to the 2000 US population and adjusting for age and sex tells a different story: the Army suicide rate drops below the US population suicide rate in 8 of the 12 years reported, giving the impression that soldiers fared better than did the US population with regard to suicide. Moreover, these adjusted Army rates deviate substantially from the crude rates, suggesting that suicide prevention initiatives are unnecessary.

When the general US population is adjusted to look like the Army population, the message is in line with what has been emphasized to Army senior leaders for the past several years: soldiers
are dying by suicide at a rate greater than the rate in the US population. As evidenced by the overlapping trend lines, the age- and sex-adjusted rates calculated using the Army population distributions from 2004 and 2015 produced similar results.

Historically, BSHOP used the 2004 Army population distribution as the standard when calculating adjusted rates. Now the 2015 Army population distribution has been selected as the new standard for several reasons. First, after concluding it is important to produce adjusted rates, one must determine which factors need adjusting. Although any factor is a potential candidate, limitations of available data or the amount of effort required will likely constrain choices. Generally, it is important to start by considering

### TABLE 1—Direct Adjusted Suicide Rates Using Different Standard Populations: United States, 2004–2015

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*The US Army and US populations were standardized to the 2000 US Census population distribution.

*The US Army and US populations were age- and sex-adjusted to the 2000 US Census population distribution.

*The US Army and US populations were standardized to the 2004 US Army population distribution.

*The US Army and US populations were standardized to the 2015 US Army population distribution.

*The US Army and US populations were standardized separately from the US Army population distribution for each year from 2008 to 2015.
broad categories of sociodemographic factors. Age, as recommended by the Department of Health and Human Services and the National Center for Health Statistics, will be the most important and common adjustment because so many medical conditions vary with age with regard to incidence, prevalence, severity, and mortality. Depending on the specific outcome, other factors, such as sex, may also be important if the outcome is known to vary by sex, as is the case for suicide.

Second, this is the appropriate option because rates adjusted on the basis of the most recent Army population distribution resulted in only minor differences from rates adjusted on the basis of the 2004 distribution. Because the US Army population distributions for 2004 and 2015 are similar, choice of the more recent year will prevent stakeholders from asking about the use of a population distribution that is 11 years old. It also reflects the drawdown from 561,980 Regular Army soldiers in 2010 to a potential low of 471,272 in 2016.27

Moreover, 2015 was the first year when all military occupations were opened to women.28 Full integration into the combat-related occupations previously closed to women will take time, and several years will pass before it becomes clear whether these expanded opportunities will result in changes in the proportion and age distribution of women in the Army.

LIMITATIONS

This study is not without limitations and additional considerations. Presentation of a single adjusted rate to represent a population risks masking, and thus misrepresenting, the heterogeneity of rates in the characteristics used for adjustment. For example, a decreasing suicide rate among soldiers aged 17 to 24 years concurrent with an increasing rate among soldiers aged 25 to 34 years will not be recognized if only an overall age-adjusted rate is presented. Ideally, both the adjusted and the crude rates for each characteristic will be presented. Were there enough cases in all groups, one would want to compare age-adjusted rates for men and women separately to examine the pattern of relative differences between the Army and the US population. One would also want to compare sex-adjusted rates for various age groups to see how those differed. Unfortunately, such comparisons are not possible for Army suicide rates because there are too few suicides by female soldiers for rates in these subgroups to be stable.

Moreover, because suicide among Army soldiers is a rare
event (<0.02% of the population), a change of 1 or 2 suicides during a specific period has a large impact on suicide rates. It is notable that because we calculated the US civilian rates using the same age distribution (17–64 years) as that of the Army population in 3 of the methods, the US population crude rates in this investigation are higher than those normally reported by the National Center for Health Statistics. Moreover, changes over the years in the rate calculation methodologies used in the DOD Suicide Event Report are most likely responsible for the small differences in the crude rates we found compared with those in that report. Last, we included only Regular Army soldiers. Future studies should explore developing a standard population for National Guard and Reserve soldiers to facilitate appropriate comparison with other populations.

PUBLIC HEALTH IMPLICATIONS

What criteria should be applied to the selection of a military service–specific standard population? Although there are no hard and fast rules for choosing the appropriate standard population, the following are a few points to consider.

First, consider the pros and cons of using an internal (a military population distribution) or external (a US population distribution) standard population. In calculating rates for a service-specific population, there are theoretically 2 options: (1) weight the service-specific population to match the standard population for the characteristics of interest (sex, age, sex–age distribution), or (2) weight the US population to match the characteristics of interest to the service-specific population (the approach we used in this investigation). The first option does not account for the differences in the age and sex distribution between the Army and the US population. The Army is younger and predominately male (86%), whereas the US population is half female, half male, and older. However, rates age-adjusted to the 2000 US population (the usual standard under the first option) may be compared with adjusted mortality rates produced by other government agencies, many of which use the same standard. The second option avoids the technical problem of assigning extremely large weights to sparsely populated subgroups in the services.

The US population decreases relatively little when adjacent 5-year age–sex groups are compared, whereas in the Army or other services, the number of service members decreases dramatically across older age–sex groups. For example, there are relatively few female soldiers aged between 50 and 60 years, and there are many women in that age group in the US population. Thus, the 3 Army distributions used in this investigation (2004, 2015, and by year) take into account the unique population distribution of the Army. However, because service-specific standard populations are not often used for adjustment by external organizations, comparison across populations is usually not feasible. The decision tree is a good educational tool for stakeholders to use when charged with comparing rates between different populations.

Second, because of the nuances and importance of this issue, the DOD might want to consider expanding current guidance to include a standardized approach for calculating adjusted rates. A standardized methodology would be of value for comparing suicide rates not only between the Army and the US population but between the services as well. This methodology could be extended to all mortality rates, as there are age and sex differences for various natural diseases, unintentional deaths, and other causes of death. The DOD might also consider developing a force composite standard (i.e., a DOD standard for all services and branches combined) for the calculation and comparison of rates across the services. The use of a single standard is important for comparability across published studies and among organizations. A single standard, consistently used, would reduce the confusion that occurs when different organizations report different comparison results for the same measure (e.g., US vs Army suicide rates).

Moreover, a DOD standard would allow the adjustment of other factors of interest (rank and pay grade) when comparing rates across military populations.

Third, it is important to remain cognizant of the magnitudes of...
Does the rate comparison involve different populations?

- No
  - Recommendation: Calculate crude rates and compare.

- Yes
  - Do the comparison populations differ on sociodemographic characteristics associated with the condition for which rates will be calculated (age? sex? race? rank?)
    - See “Consideration 1”
      - Yes
        - Recommendation: Calculate crude rates stratified on the differing characteristic(s) and compare.
          - Example: Stratify rates of motor vehicle accidents by age for the US Army and do the same for the US population and compare rates between age groups.
      - No
        - Recommendation: Calculate standardized rates adjusted for the same characteristics to the same standard population as the comparison rates.
          - Example: If comparison rates are standardized to the 2000 US population distribution and adjusted for age, use the 2000 US population distribution and adjust for age to standardize the rates.

- Is a single summary measure needed?
  - Yes
    - Examine the trends of crude rates stratified by the differing characteristics: are they roughly parallel?
      - See “Consideration 2”
        - Yes
          - Recommendation: Calculate standardized rates adjusted for the same characteristics to the same standard population as the comparison rates.
        - No
          - Consider selecting a different standard population. When adjusted rates deviate substantially from crude rates the layperson may find interpretation difficult.

- No
  - Consider selecting the most recent of the standard populations that fit the above criteria.

- Are the counts small in any of the group categories?
  - Yes
    - Consider aggregating group categories.
      - See “Consideration 4”
  - No
    - Are the trends of the adjusted rates similar to those of the corresponding crude rates?
      - Yes
        - Consider selecting the most recent of the standard populations that fit the above criteria.
      - No
        - Recommendation: Choose a standard population and calculate standardized rates adjusted for the differing characteristic(s).
          - See “Consideration 3”

Consideration 1:
- If unknown, review the literature and examine the distribution of characteristics in the populations to be compared.

Consideration 2:
- If rates are not roughly parallel, a summary measure can still be reported. Include the appropriate caveats regarding the analysis and report crude rates of differing characteristics, if possible.

Consideration 3:
- Aggregating minimizes the influence of applying large weights where case counts are low and the denominators in subgroups differ.
- Example: The largest weight from the 2000 US population is for age ≥ 45 y, but in the Army that age group has the smallest number of events as well as a small denominator so that the rate for that age group is large. Thus, the weighted rate contributes substantially to the adjusted rate.

Consideration 4:
- Example: Comparing US & Colorado
  - Potential Standard
    - US & Colorado
    - 2000 US distribution
  - Decision: Choose a standard population and calculate standardized rates adjusted for the differing characteristic(s).

FIGURE 3—Decision Tree to Guide Scientists in Selecting Rates (Crude, Stratified, or Adjusted) and Standard Populations
the rates and of the populations under study. For instance, in 2012, the crude rates for the US and Army populations were 16.5 and 30.1 per 100,000 people, respectively, which was the greatest discrepancy observed among crude rates (Table 1). The difference between these rates amounts to 13.6 deaths per 100,000 people, or approximately 0.0001% (1 one hundredth of a percent).

Furthermore, traditional tests of statistical significance that directly compare the 2 populations may be of limited value in this study. Because the Army population is a subset of the US population, assumptions of independence are violated. Moreover, because the denominators are so large, the P values, which are highly dependent on sample size, would be likely to suggest strong associations even for the smallest observed differences. Thus, it is essential to understand the practical significance rather than the statistical significance in the observed suicide rates.

The Army population has changed dramatically over the past 15 years, with a rapid increase following September 11, 2001, and steady downsizing since 2011. However, what matters most in adjusted rate calculations are the changes in the age and sex proportions of a population over time. Although the Army anticipates an increase in the proportion of female soldiers over the next 5 to 10 years now that more combat-related jobs are open to women, the age of new soldiers will likely continue to skew young, in accordance with established enlistment standards. Which ever standard is chosen should be maintained for a number of years and revisited periodically to determine whether a new standard is more appropriate.

**CONTRIBUTORS**


**ACKNOWLEDGMENTS**

Analytic support was provided by the Armed Forces Health Surveillance Branch of the Public Health Division at the Defense Health Agency.

The authors would like to acknowledge support from the following individuals: Amy Millikan Bell, MD, MPH, Masha Toussaint, PhD, MPH, Katherine Schaughency, PhD, MHS, Angela Mound, MS, and Lawrence Rasoulyan, MPH.

**Note.** The views expressed in this publication are those of the authors and do not necessarily reflect the official policy or position of the Department of the Army, the Department of Defense, or the US government.

**HUMAN PARTICIPANT PROTECTION**

The Public Health Review Board of the US Army Public Health Center approved this study as Public Health Practice under no. 16–500M1 Division of Behavioral and Social Health Outcomes Practice, Public Health Surveillance and Monitoring Activities Umbrella Project Plan.

**REFERENCES**


