

Sociodemographic and career history predictors of suicide mortality in the United States Army 2004–2009

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Background. The US Army suicide rate has increased sharply in recent years. Identifying significant predictors of Army suicides in Army and Department of Defense (DoD) administrative records might help focus prevention efforts and guide intervention content. Previous studies of administrative data, although documenting significant predictors, were based on limited samples and models. A career history perspective is used here to develop more textured models.

Method. The analysis was carried out as part of the Historical Administrative Data Study (HADS) of the Army Study to Assess Risk and Resilience in Servicemembers (Army STARRS). De-identified data were combined across numerous Army and DoD administrative data systems for all Regular Army soldiers on active duty in 2004–2009. Multivariate associations of sociodemographics and Army career variables with suicide were examined in subgroups defined by time in service, rank and deployment history.

Results. Several novel results were found that could have intervention implications. The most notable of these were significantly elevated suicide rates (69.6–80.0 suicides per 100 000 person-years compared with 18.5 suicides per 100 000 person-years in the total Army) among enlisted soldiers deployed either during their first year of service or with less than expected (based on time in service) junior enlisted rank; a substantially greater rise in suicide among women than men during deployment; and a protective effect of marriage against suicide only during deployment.

Conclusions. A career history approach produces several actionable insights missed in less textured analyses of administrative data predictors. Expansion of analyses to a richer set of predictors might help refine understanding of intervention implications.

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Introduction

The US military suicide rate, although historically below the civilian rate, has climbed steadily since

the beginning of the Iraq and Afghanistan conflicts (Armed Forces Health Surveillance Center, 2012) and has exceeded the matched civilian rate since 2008 (Kuehn, 2009). Successful interventions to address this problem will require improved understanding of risk factors. The Army Study to Assess Risk and Resilience in Servicemembers (Army STARRS; www.armystarrs.org) is a multi-component

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epidemiological–neurobiological study designed to help provide this understanding. As described in more detail elsewhere (Kessler *et al.* 2013), Army STARRS includes large-scale cross-sectional surveys of new soldiers and of all soldiers exclusive of those in training, a panel survey of combat brigades assessed shortly before and after returning from deployment, neurocognitive tests and blood samples obtained from survey respondents, linkage of survey data to administrative data, and retrospective case–control studies of attempted and completed suicides. Another Army STARRS component is the Historical Administrative Data Study (HADS) (Kessler *et al.* 2013). The HADS combines information culled from numerous Army and Department of Defense (DoD) administrative databases for all soldiers on active duty in 2004–2009, including information on manner and timing of death.

Prior Army studies of administrative predictors of suicide, while limited either to descriptive analyses of suicides without controls (Logan *et al.* 2012; Bush *et al.* 2013), bivariate comparisons (Black *et al.* 2011; Schoenbaum *et al.* *in press*), or simple multivariate comparisons (Bell *et al.* 2010; Hyman *et al.* 2012) documented a number of sociodemographic (e.g. male, young) and Army career (e.g. low rank, deployment history) predictors. Speculation also exists that multiple deployments, long deployments and short dwell times (times between end of one deployment and beginning of next) might be risk factors for suicide (Rona *et al.* 2007; Reger *et al.* 2009).

While the current report presents the first multivariate HADS results, an earlier HADS report of bivariate predictors found that male sex, lower enlisted rank, history of deployment and being unmarried were associated with suicide (Schoenbaum *et al.* *in press*). That report also documented significant changes in associations of basic sociodemographics with suicide over the course of the military career, leading to the multivariate analyses reported here. We focus on associations of key sociodemographic and career history variables with suicide separately among enlisted soldiers and officers in the first 4 years of service (the typical first term of enlistment) and later years of service, distinguishing soldiers who never deployed, were currently deployed, and who previously deployed. This career history perspective is also motivated by emerging life history models of suicide that emphasize windows of opportunity to target interventions at developmentally appropriate stages (Fergusson *et al.* 2000; Gunnell & Lewis, 2005; Riordan *et al.* 2006; Seguin *et al.* 2007; Shiner *et al.* 2009; Maniglio, 2011; Mittendorfer-Rutz *et al.* 2012).

Method

Sample

De-identified HADS data were analysed from: (a) the DoD Defense Manpower Data Center (DMDC) Master Personnel and Transaction Files (sociodemographic and Army career characteristics); (b) the DMDC Contingency Tracking System (activations, mobilizations, deployments); and (c) the Armed Forces Medical Examiner Tracking System (suicides). We focused on HADS records for the 975 057 Regular Army soldiers (excluding activated Army National Guard and Army Reserve) on active duty at some time between 1 January 2004 and 31 December 2009, 569 of whom completed suicide during that active duty time period. As detailed below in the section on analysis methods, we analysed these data using a discrete-time survival framework with person-month the unit of analysis (Willett & Singer, 1993). This approach treats each month in the career of each soldier as a separate observational record. There were approximately 37 million person-months in the study period; only 569 of them coded 1 on the dichotomous yes/no suicide outcome variable. Rather than include this enormous number of control person-months in the analysis, we took advantage of the fact that discrete-time survival coefficients can be estimated without bias when control person-months are randomly subsampled and weighted using the logic of case–control analysis (Schlesselman, 1982) and selected an equal-probability 1:400 sample of control person-months stratified by sex, rank, time in service, deployment history (never, currently, previously) and historical time ($n=92\,507$) from the population. These controls were combined with the 569 suicide person-months to create a case–control sample of 93 076 person-months. Each control person-month was assigned a weight of 400 to adjust for under-sampling. HADS data collection and analysis were approved by the Human Subjects Committees of the Uniformed Services University of the Health Sciences for the Henry M. Jackson Foundation (the primary grantee), the University of Michigan Institute for Social Research (site of the Army STARRS Data Enclave) and Harvard Medical School (site of data analysis).

Measures

Although the data considered here are limited to sociodemographic and Army career variables, additional HADS data are being collected (e.g. on mental and physical health care utilization and criminal justice) but were not available for the current analysis. Administrative data are also being merged with the Army STARRS survey data to facilitate more in-depth

analysis of associations in the HADS data for the roughly 100 000 soldiers who participated in these surveys. The sociodemographics considered here include age, sex, race–ethnicity, education, marital status and number of dependants. The Army career variables include enlistment age, time in service, rank, and history of deployments to a combat zone or in direct support of Operation Enduring Freedom in Afghanistan or Operation Iraqi Freedom. We also considered length of current deployment, time since returning from most recent deployment, and dwell time (amount of time between end of one deployment and beginning of the next) among soldiers with a history of multiple deployments. Time-varying variables were coded at current values in each person-month.

Analysis methods

As noted above, discrete-time survival analysis with person-month the unit of analysis was used to examine associations of predictors with suicide. Logistic regression analysis was used to predict a yes/no suicide outcome controlling for time in service. When used to analyse this type of person-month data array, logistic regression coefficients can be interpreted as discrete-time survival coefficients (Willett & Singer, 1993). All models also included controls for calendar month based on the suicide rate increasing over the study period (Black *et al.* 2011). The implicit assumption that odds ratios (ORs) do not vary over time was tested and, consistent with earlier bivariate HADS results (Schoenbaum *et al.* in press), was supported.

Before estimating the models, simple cross-tabulations were used to examine subgroups defined by a coarse cross-classification of rank (enlisted *v.* officer), time in service (0–4 *v.* more than 4 years) and deployment history (never, currently, previously). The suicide rate was sufficiently different across the six enlisted soldier subgroups that models were estimated separately in each. The number of suicides among officers, in comparison, was so small that the model was estimated only for all officers combined.

A three-step process was used to build the models. First, we examined bivariate associations and discretized ordered predictors (e.g. age at enlistment, years of education) to capture functional forms of associations with suicide. The two variables consistently non-significant in this step (race–ethnicity and number of dependants) were excluded from further analysis.

Second, joint associations were estimated for the two pairs of predictors found in the first step to be strongly related with each other: time in service with age; and rank with education. Age and education were excluded from further analysis based on neither

predicting suicide net of time in service and rank. We also examined joint associations of rank and time in service with suicide and found several important interactions that were built into the final analysis step.

Third, pooled multivariate survival models were estimated separately for enlisted soldiers and officers to evaluate global interactions of sociodemographic and Army career variables with time in service and deployment history. Less complex models were then estimated based on results of significance tests. Significance was evaluated using 0.05-level two-sided tests. Global significance was evaluated using Wald χ^2 tests.

Final model coefficients were then used to calculate standardized suicide rates (Roalfe *et al.* 2008); that is, estimated numbers of suicides per 100 000 person-years (PY) for each category of each predictor under the model assuming other predictors were at their sample-wide means. Final model coefficients were also used to estimate population attributable risk (PAR) of suicides associated with targeted predictors based on simulation methods (Hanley, 2001). PAR can be interpreted as the proportion of observed suicides that might have been prevented if the predictor variable coefficients represented causal effects and interventions could have been implemented to eradicate these effects (Rothman & Greenland, 1998).

Results

Suicide rates by rank, time in service and deployment history

The mean suicide rate was 18.5/100 000 PY. Only two of 12 subgroups created by cross-classifying rank, time in service and deployment history had rates meaningfully higher than this mean: currently and previously deployed enlisted soldiers in their first 4 years of service (31.3–29.4/100 000 PY). The vast majority (90.9%) of Regular Army suicides were completed by enlisted soldiers (51.3% during the first 4 years of service and 39.5% after more time in service). Officers, making up 16.4% of all Regular Army personnel, accounted for the remaining 9.1% of suicides. Only five officers completed suicide during their first 4 years of service, while the suicide rate among officers with more than 4 years of service was low and unrelated to deployment status (11.3/100 000 PY) (Tables 1 and 2).

Thinking in career history terms and focusing only on enlisted soldiers, the suicide rate during the first 4 years of service was about 70% higher among currently deployed (31.3/100 000 PY) and previously deployed (29.4/100 000 PY) than never-deployed (18.4/100 000 PY) soldiers. Among enlisted soldiers

Table 1. Suicide rate (suicides/100 000 person-years) by rank, time in service and deployment history among Regular Army soldiers in the Army STARRS 2004–2009 Historical Administrative Data Systems sample ($n=93\,076$)^a

	Deployment history							
	Never		Currently		Previously		Total	
	Suicide rate	(n_1/n_2^b)	Suicide rate	(n_1/n_2^b)	Suicide rate	(n_1/n_2^b)	Suicide rate	(n_1/n_2^b)
Enlisted soldiers								
First 4 years in service	18.4	(128/697)	31.3	(90/287)	29.4	(74/252)	23.6	(292/1236)
More than 4 years in service	12.1	(42/346)	13.1	(41/314)	20.8	(142/683)	16.8	(225/1343)
Total	16.3	(170/1043)	21.8	(131/601)	23.1	(216/935)	20.1	(517/2579)
Officers								
First 4 years in service	5.8	(3/51)	0.0	(0/20)	11.6	(2/17)	5.7	(5/88)
More than 4 years in service	14.3	(20/140)	11.5	(9/78)	9.0	(18/199)	11.3	(47/417)
Total	12.0	(23/191)	9.2	(9/98)	9.2	(20/216)	10.3	(52/505)
All soldiers: enlisted and officers								
First 4 years in service	17.5	(131/748)	29.3	(90/307)	28.3	(76/269)	22.4	(297/1324)
More than 4 years in service	12.8	(62/486)	12.8	(50/392)	18.1	(160/882)	15.5	(272/1760)
Total	15.6	(193/1234)	20.0	(140/699)	20.5	(236/1151)	18.5	(569/3084)

Army STARRS, Army Study to Assess Risk and Resilience in Servicemembers.

^a The sample of 93 076 person-months includes all 569 suicides of active duty Regular Army soldiers recorded in the administrative records during the years 2004–2009 plus a 1:400 stratified probability sample of all other person-months in the population exclusive of those associated with other types of death (i.e. combat death, homicide, and death due to other injuries or illnesses). All records in the 1:400 sample were assigned a weight of 400 to adjust for the under-sampling months not associated with suicide.

^b n_1 =number of suicides; n_2 =number of person-years, not person-months, in thousands in the population. As noted in note a, the 93 076 person-months in the sample represent a 1:400 sample of the 37.0 million person-months (3.084 million person-years) in the population of Regular Army soldiers (i.e. excluding those in the US Army National Guard and Army Reserve) on active duty for 1 or more month in the calendar years 2004–2009.

with more years in service, the suicide rate was consistently (across deployment history categories) lower than among those in their first 4 years of service. Among enlisted soldiers with more than 4 years of service, in comparison, the suicide rate was relatively similar for the currently (13.1/100 000 PY) and never (12.1/100 000 PY) deployed but considerably higher among the previously deployed (20.8/100 000 PY).

Testing for variation in suicide risk by time in service and deployment history

Officers

Among officers with more than 4 years of service, associations (ORs) of sociodemographic and Army career predictors with suicide did not vary significantly by either time in service ($\chi^2_{11}=16.4$, $p=0.13$) or deployment history ($\chi^2_{14}=15.4$, $p=0.35$). Nor did any of the socio-demographic or Army career variables predict suicide significantly in a multivariate additive model among officers. Given these results, the remaining analyses focused on enlisted soldiers.

Enlisted soldiers

Global interaction tests showed that the associations of sociodemographic and Army career predictors with suicide among enlisted soldiers varied significantly by deployment history ($\chi^2_{16}=41.5$, $p<0.001$) but not time in service ($\chi^2_8=1.9$, $p=0.99$) or the conjunction of deployment history and time in service ($\chi^2_{11}=11.5$, $p=0.16$). We consequently estimated a final enlisted soldier model retaining all significant two-way interactions with deployment history in addition to all main effects. Standardized suicide rates and PAR simulations were based on this model.

Associations of predictors with suicide among enlisted soldiers

Sex

Enlisted males had higher odds of suicide than females in all subgroups. However, the male:female OR was lower (and not statistically significant) among currently deployed (1.8) than never-deployed or

Table 2. Percentages of all active duty Regular Army suicides and soldiers by rank, time in service, and deployment history among Regular Army soldiers in the Army STARRS 2004–2009 Historical Administrative Data Systems sample ($n=93\,076$)^a

	Deployment history							
	Never		Currently		Previously		Total	
	Suicides	Soldiers	Suicides	Soldiers	Suicides	Soldiers	Suicides	Soldiers
Enlisted soldiers								
First 4 years in service	22.5	22.6	15.8	9.3	13.0	8.2	51.3	40.1
More than 4 years in service	7.4	11.2	7.2	10.2	25.0	22.2	39.5	43.5
Total	29.9	33.8	23.0	19.5	38.0	30.3	90.9	83.6
Officers								
First 4 years in service	0.5	1.7	0.0	0.6	0.4	0.6	0.9	2.9
More than 4 years in service	3.5	4.5	1.6	2.5	3.2	6.5	8.3	13.5
Total	4.0	6.2	1.6	3.2	3.5	7.0	9.1	16.4
All soldiers: enlisted and officers								
First 4 years in service	23.0	24.3	15.8	9.9	13.4	8.7	52.2	42.9
More than 4 years in service	10.9	15.7	8.8	12.7	28.1	28.6	47.8	57.1
Total	33.9	40.0	24.6	22.6	41.5	37.3	100.0	100.0

Army STARRS, Army Study to Assess Risk and Resilience in Servicemembers.

^a The sample of 93 076 person-months includes all 569 suicides of active duty Regular Army soldiers recorded in the administrative records during the years 2004–2009 plus a 1:400 stratified probability sample of all other person-months in the population exclusive of those associated with other types of death (i.e. combat death, homicide, and death due to other injuries or illnesses). All records in the 1:400 sample were assigned a weight of 400 to adjust for the under-sampling months not associated with suicide.

previously deployed (5.0) soldiers (Table 3). This difference was due to the female suicide rate among the currently deployed being substantially higher than among the never deployed (a 3.8-fold higher rate, 14.2 *v.* 3.7/100 000 PY, during the first 4 years of service; and a 2.4-fold higher rate, 6.5 *v.* 2.7/100 000 PY, during later years of service), whereas currently deployed males had a rate only slightly higher than that of never-deployed males during the first 4 years of service (25.5 *v.* 18.4/100 000 PY) and somewhat lower than the never deployed during later years of service (11.6 *v.* 13.6/100 000 PY). Furthermore, after returning from deployment the suicide rate among women returned nearly to the pre-deployment level but either remained elevated (during the first 4 years of service) or increased (during later years of service) among men.

Marital status

The suicide rate was significantly higher (OR=1.8) among unmarried than married soldiers during deployment regardless of time in service, but unrelated to marital status among the never and previously deployed. This difference in ORs was due partly to the suicide rate being significantly higher among

currently than never-deployed unmarried soldiers (29.8 *v.* 13.8/100 000 PY) but only insignificantly higher among currently than never-deployed married soldiers (17.1 *v.* 13.9/100 000 PY). Furthermore, after returning from deployment the suicide rate among married soldiers increased (21.9 *v.* 17.1/100 000 PY during the first 4 years of service; 17.7 *v.* 9.4/100 000 PY during later years of service), while the suicide rate either decreased (during the first 4 years of service; 21.9 *v.* 29.8/100 000 PY) or remained the same (in later years of service) among unmarried soldiers.

Enlistment age

Similar to the pattern for marital status, enlistment age was associated with suicide only during deployment. Specifically, the suicide rate of currently deployed enlisted soldiers was significantly higher (OR=1.6) among those who enlisted as teenagers than at later ages, while enlistment age was unrelated to suicide (OR=0.9) among the never deployed and previously deployed. This significant variation in ORs was due partly to the suicide rate of soldiers enlisting as teenagers being much higher among the currently than never deployed (30.1/100 000 PY *v.* 13.4/100 000 PY during the first 4 years of service; 13.6/100 000 PY

Table 3. Multivariate associations (ORs) of age at enlistment, rank/time in service and deployment history with suicide among enlisted soldiers in the Army STARRS 2004–2009 Historical Administrative Data Study sample (n=77 610)^a

	ORs by deployment history				Standardized suicide rates by time in service and deployment history							
	Never		Current		Previous		First 4 years in service			More than 4 years in service		
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	Never	Current	Previous	Never	Current	Previous
Sex												
Male	5.0	(2.8–8.6)*	1.8	(0.9–3.7)	5.0	(2.8–8.6)*	18.4	25.5	26.2	13.6	11.6	20.9
Female	1.0	–	1.0	–	1.0	–	3.7	14.2	5.3	2.7	6.5	4.2
χ^2	32.0*		2.6		32.0*							
Marital status												
Unmarried	1.0	(0.8–1.3)	1.8	(1.2–2.6)*	1.0	(0.8–1.3)	13.8	29.8	21.9	9.7	16.4	17.6
Married	1.0	–	1.0	–	1.0	–	13.9	17.1	21.9	9.7	9.4	17.7
χ^2	0.0		8.0*		0.0							
Enlistment age, years												
17–19	0.9	(0.8–1.2)	1.6	(1.1–2.3)*	0.9	(0.8–1.2)	13.4	30.1	21.2	9.4	13.6	17.1
20+	1.0	–	1.0	–	1.0	–	14.2	19.2	22.6	10.0	8.7	18.2
χ^2	0.4		5.6*		0.4							
Rank/time in service among soldiers in their first 4 years of service^b												
Deployed <13 MIS	–	–	3.2	(1.7–6.0)*	–	–	–	79.4	–	–	–	–
E1–E2 >18 MIS LTE	2.4	(1.6–3.6)*	2.4	(1.6–3.6)*	2.4	(1.6–3.6)*	29.9	59.8	61.6	–	–	–
E3 >24 MIS LTE	2.8	(2.0–4.1)*	0.9	(0.3–2.5)	2.8	(2.0–4.1)*	35.6	22.7	73.2	–	–	–
Other E1–E4	1.0	–	1.0	–	1.0	–	12.5	25.0	25.7	–	–	–
E5–E6	0.2	(0.1–0.6)*	0.2	(0.1–0.6)*	0.2	(0.1–0.6)*	2.8	5.6	5.8	–	–	–
χ^2_{3-4}	59.1*		70.4*		59.1*							
Rank/time in service among soldiers with more than 4 years of service^b												
E1–E4	1.0	–	1.0	–	1.0	–	–	–	–	15.9	17.4	28.8
E5–E6	0.6	(0.4–0.8)*	0.6	(0.4–0.8)*	0.6	(0.4–0.8)*	–	–	–	9.1	9.9	16.4
E7–E9	0.5	(0.3–0.8)*	0.5	(0.3–0.8)*	0.5	(0.3–0.8)*	–	–	–	8.1	8.8	14.6
χ^2	15.5*		15.5*		15.5*							
History of prior deployment												
Yes	–	–	1.0	(0.8–1.3)	1.0	(0.8–1.3)	–	24.2	22.0	–	11.0	17.7
No	–	–	1.0	–	1.0	–	–	24.0	21.9	–	11.0	17.6
χ^2	–		0.0		0.0							

Time in current deployment, months												
0-3	-	-	1.0	-	-	-	-	18.6	-	-	8.4	-
4-6	-	-	1.6	(1.0-2.5)	-	-	-	29.0	-	-	13.1	-
7-9	-	-	1.4	(0.8-2.4)	-	-	-	25.7	-	-	11.7	-
10+	-	-	1.4	(0.8-2.2)	-	-	-	25.3	-	-	11.5	-
χ^2				3.4								
Time since returning from most recent deployment, months												
0-3	-	-	-	-	1.0	-	-	-	16.2	-	-	12.4
4-6	-	-	-	-	1.8	(1.1-2.9)*	-	-	28.6	-	-	21.8
7-12	-	-	-	-	1.3	(0.8-2.1)	-	-	21.0	-	-	16.0
13+	-	-	-	-	1.6	(1.0-2.4)	-	-	25.1	-	-	19.1
χ^2						5.9						
Dwell time ratio ^c												
Q1	-	-	0.9	(0.6-1.4)	0.9	(0.6-1.4)	-	21.8	19.9	-	10.1	16.2
All others	-	-	1.0	-	1.0	-	-	24.1	22.0	-	11.2	17.9
χ^2				0.2		0.2						
Subjects, <i>n</i>							21031	8404	7373	10414	9454	20634

OR, Odds ratio; Army STARRS, Army Study to Assess Risk and Resilience in Servicemembers; CI, confidence interval; MIS, months in service; LTE, less than expected rank given time in service, representing soldiers that either were not promoted on time or were demoted; dwell time, number of months between end of second most recent deployment and beginning of most recent deployment; dwell time ratio, dwell time divided by duration of second most recent deployment; Q1, lowest quartile of the dwell time ratio in the population (less than or equal to 0.84).

^a The sample of 77 610 person-months includes all 517 suicides of active duty Regular Army enlisted soldiers recorded in the administrative records during the years 2004-2009 (note that this number excludes all officers) plus a 1:400 stratified probability sample of all other person-months in the population of Regular Army enlisted soldiers exclusive of those associated with other types of death (i.e. combat death, homicide, and death due to other injuries or illnesses). All records in the 1:400 sample were assigned a weight of 400 to adjust for the under-sampling months not associated with suicide.

^b Based on multivariate logistic regression equations in subgroups of enlisted soldiers defined by the cross-classification of rank, time in service and deployment history. As described in the text, coefficients were constrained to be equal across subgroups defined by time in service based on an insignificant global significance test of interactions between the predictors and time in service. However, the coefficients were allowed to vary with deployment history when this variation was significant based on a significant global interaction test between the predictors and deployment history.

^c Dwell time is defined only for soldiers with two or more deployments.

* $p < 0.05$ (two-sided test).

v. 9.4/100000 PY during later years of service), which was not the case for soldiers enlisting at later ages (19.2/100000 PY v. 14.2/100000 PY during the first 4 years of service; 8.7/100000 PY v. 10.0/100000 PY during later years of service). Changes in suicide rates after returning from deployment also differed by age at enlistment. During the first 4 years of service, when the overall suicide rate was lower among the previously than currently deployed, this post-deployment lowering was confined to soldiers who enlisted as teenagers (21.2/100000 PY among the previously deployed v. 30.1/100000 PY among the currently deployed), whereas among soldiers who enlisted at older ages the suicide rate was slightly higher after returning from deployment than during deployment (22.6/100000 PY among the previously deployed v. 19.2/100000 PY among the currently deployed). In later years of service, the elevated suicide rate of previously than currently deployed soldiers was less pronounced among those who enlisted as teenagers (17.1/100000 PY v. 13.6/100000 PY) than at later ages (18.2/100000 PY v. 8.7/100000 PY).

Rank/time in service

Significant interactions were found between rank and a fine-grained measure of time in service. One of these interactions involved soldiers deployed in their first year of service. While making up only 5.7% of currently deployed soldiers with less than 4 years in service, these relatively inexperienced soldiers accounted for nearly 15% of all suicides.

Other interactions involved high suicide rates among lower-ranking enlisted soldiers (i.e. E1–E4) with less than expected (LTE) rank based on time in service (i.e. E1–E2 with more than 18 months in service and E3 with more than 24 months in service). Significantly elevated ORs associated with LTE rank were in the range 2.4–2.8. The only exception was an insignificant OR of LTE E3 rank among the currently deployed (0.9). (Further analysis, results available on request, shows that the elevated ORs associated with LTE were comparable for soldiers who were demoted and those not promoted on schedule.) Inspection of standardized suicide rates shows that the suicide rate of soldiers with LTE rank among the never deployed was more than twice as high as among other junior enlisted soldiers (29.9–35.6/100000 PY v. 12.5/100000 PY). Among currently deployed soldiers, the standardized suicide rate of LTE E1–E2 soldiers was much higher than that of other junior enlisted soldiers (59.8/100000 PY v. 25.0/100000 PY). A similar pattern was found among previously deployed soldiers, where the suicide rate of those with LTE rank was 61.6–73.2/100000 PY v. 25.7/100000 PY for other junior

enlisted soldiers. At the other extreme, the relatively small proportion of higher ranking enlisted soldiers with less than 4 years of service (made up almost entirely of E5–E6) had consistently low suicide rates (2.8–5.8/100000 PY). Among enlisted soldiers with more than 4 years of service, in comparison, the suicide rate was inversely related to rank, only about 10% higher among the currently than never deployed, and 65% higher among the previously than currently deployed, with the highest rate (28.8/100000 PY) among previously deployed junior rank enlisted soldiers.

Deployment timing and history

Neither time in current deployment ($\chi^2_3=3.4$, $p=0.34$), time since returning from deployment ($\chi^2_5=5.9$, $p=0.12$), history of multiple deployments ($\chi^2_1=0.0$, $p=0.96$), nor dwell time [examined both in absolute terms (i.e. number of months between end of second most recent deployment and beginning of most recent deployment) and in relative terms (i.e. length of absolute dwell time divided by length of prior deployment)] ($\chi^2_1=0.07$ – 0.19 , $p=0.78$ – 0.66) was significantly related to suicide.

PARs

PAR is a joint function of standardized risk (Table 3) and prevalence (Table 4) of predictors.

Sex

How much would the overall Army suicide rate be affected if the higher suicide rate of enlisted women during deployment than among the never deployed could be reduced to the same ratio as men? PAR suggests that such a change would reduce total suicides of currently deployed enlisted soldiers by 3.8% in the first 4 years of service and 4.1% in later years. These relatively low percentages reflect the low proportion of deployed soldiers who are women (9.9% during first 4 years of service; 9.2% during later years) and the fact that women have a much lower overall suicide rate than men.

Marital status and enlistment age

How much would the overall Army suicide rate be reduced if the elevated suicide rates during deployment of unmarried enlisted soldiers and those who enlisted as teenagers could be reduced to the same proportional elevations as among the married and soldiers with later enlistment ages? PAR for marriage is 32.4% of all suicides completed by currently deployed enlisted soldiers in their first 4 years of service and 18.3% in later years. PAR for young enlistment age is

Table 4. Distributions of predictor variables in the Army STARRS 2004–2009 Historical Administrative Data Systems sample exclusive of officers in the first 4 years in service (n=90173)^a

	Enlisted soldiers first 4 years in service			Enlisted soldiers more than 4 years in service			Officers more than 4 years of service
	Never deployed	Currently deployed	Previously deployed	Never deployed	Currently deployed	Previously deployed	
Sex							
Female	17.9 (0.3)	9.9 (0.3)	11.1 (0.4)	21.1 (0.4)	9.2 (0.3)	10.5 (0.2)	14.2 (0.3)
Male	82.1 (0.3)	90.1 (0.3)	88.9 (0.4)	78.9 (0.4)	90.8 (0.3)	89.5 (0.2)	85.8 (0.3)
Marital status							
Currently married	30.6 (0.3)	38.6 (0.5)	44.4 (0.6)	71.0 (0.4)	71.1 (0.5)	73.3 (0.3)	77.8 (0.4)
Not currently married	69.4 (0.3)	61.4 (0.5)	55.6 (0.6)	29.0 (0.4)	28.9 (0.5)	26.7 (0.3)	22.2 (0.4)
Deployment history							
Never deployed	100.0 (0.0)	–	–	100.0 (0.0)	–	–	33.5 (0.4)
Currently deployed	–	100.0 (0.0)	–	–	100.0 (0.0)	–	18.7 (0.3)
Previously deployed	–	–	100.0 (0.0)	–	–	100.0 (0.0)	47.8 (0.4)
Age at enlistment, years							
17–19	46.7 (0.3)	50.0 (0.5)	50.2 (0.6)	50.0 (0.5)	52.5 (0.5)	51.3 (0.3)	–
20+	53.3 (0.3)	50.0 (0.5)	49.8 (0.6)	50.0 (0.5)	47.5 (0.5)	48.7 (0.3)	–
17–22	–	–	–	–	–	–	59.3 (0.4)
23+	–	–	–	–	–	–	40.7 (0.4)
Rank/time in service							
Deployed <13 MIS	–	5.7 (0.3)	–	–	–	–	–
E1–E2 >18 MIS LTE	5.2 (0.2)	4.2 (0.2)	3.1 (0.2)	–	–	–	–
E3 >24 MIS LTE	9.8 (0.2)	4.9 (0.2)	5.0 (0.3)	–	–	–	–
Other E1–E4	81.7 (0.3)	76.2 (0.5)	75.9 (0.5)	19.0 (0.4)	22.1 (0.4)	17.4 (0.3)	–
E5–E6	3.2 (0.1)	9.0 (0.3)	16.1 (0.4)	48.5 (0.5)	59.8 (0.5)	60.1 (0.3)	–
E7–E9	–	–	–	32.5 (0.5)	18.1 (0.4)	22.6 (0.3)	–
Warrant officer	–	–	–	–	–	–	18.4 (0.3)
Commissioned officer 1–3	–	–	–	–	–	–	40.0 (0.4)
Commissioned officer 4	–	–	–	–	–	–	21.7 (0.4)
Commissioned officer 5+	–	–	–	–	–	–	19.8 (0.4)
History of prior deployment							
Yes	–	16.1 (0.4)	9.5 (0.3)	–	65.1 (0.5)	42.1 (0.3)	28.4 (0.4)
No	–	83.9 (0.4)	90.5 (0.3)	–	34.9 (0.5)	57.9 (0.3)	71.6 (0.4)
Time in current deployment, months^b							
0–3	–	28.3 (0.5)	–	–	24.5 (0.4)	–	5.4 (0.2)
4–6	–	23.7 (0.5)	–	–	22.1 (0.4)	–	4.2 (0.2)
7–9	–	19.4 (0.4)	–	–	19.8 (0.4)	–	3.6 (0.2)
10+	–	28.5 (0.5)	–	–	33.6 (0.5)	–	5.4 (0.2)
Time since most recent deployment, months^b							
0–3	–	–	24.1 (0.5)	–	–	13.2 (0.2)	5.3 (0.2)
4–6	–	–	20.5 (0.5)	–	–	12.0 (0.2)	5.1 (0.2)
7–12	–	–	32.8 (0.5)	–	–	21.6 (0.3)	9.1 (0.3)
13+	–	–	22.6 (0.5)	–	–	53.3 (0.3)	28.3 (0.4)

Table 4 (cont.)

	Enlisted soldiers first 4 years in service			Enlisted soldiers more than 4 years in service			Officers more than 4 years of service
	Never deployed	Currently deployed	Previously deployed	Never deployed	Currently deployed	Previously deployed	
Dwell time ratio							
Q1 ^c	–	3.3 (0.2)	3.5 (0.2)	–	15.1 (0.4)	12.4 (0.2)	7.7 (0.2)
Subjects, <i>n</i>	21 031	8704	7373	10414	9454	20634	12563

Values are given as percentage (standard error).

Army STARRS, Army Study to Assess Risk and Resilience in Servicemembers; MIS, months in service, LTE, less than expected rank given time in service, representing soldiers that either were not promoted on time or were demoted; dwell time, number of months between end of second most recent deployment and beginning of most recent deployment; dwell time ratio, dwell time divided by duration of second most recent deployment; Q1, lowest quartile of the dwell time ratio in the population.

^a The sample of 90173 person-months includes all 564 suicides of active duty Regular Army soldiers recorded in the administrative records during the years 2004–2009 (note that this number excludes officers with less than 4 years of service, five of whom committed suicide) plus a 1:400 stratified probability sample of all other person-months in the population of all enlisted soldiers and the subset of officers with more than 4 years in service exclusive of those associated with other types of death (i.e. combat death, homicide, and death due to other injuries or illnesses). All records in the 1:400 sample were assigned a weight of 400 to adjust for the under-sampling months not associated with suicide.

^b Percentages among officers are defined on the base of all officers with more than 4 years in service, not only those currently or previously deployed. As a result, the percentages sum either to the proportion of such officers currently deployed (in the case of time in current deployment) or previously deployed (in the case of time since most recent deployment).

^c The proportion of officers in Q1 is calculated in the table on the base of all officers.

22.7% of all suicides completed by currently deployed enlisted soldiers in their first 4 years of service.

Early deployment and LTE rank

The two most dramatic results with potential intervention implications regarding rank and time in service are those associated with junior enlisted soldiers deployed in their first year of service or with LTE rank having significantly elevated suicide rates. Reduction of these rates to the levels among other junior enlisted soldiers would reduce the Army suicide rate by 20.3% for never deployed, 14.9% for currently deployed, and 13.6% for previously deployed enlisted soldiers in their first 4 years of service.

Discussion

Limitations of the data are: that some genuine suicides might have been inaccurately classified as accidents or undetermined (i.e. inadequate evidence to determine manner of death); that data were not available for years more recent than 2009; and that reliance on register-based data limited the range of predictors that could be studied. As noted in the Introduction, the latter limitation will be addressed in future

analyses of Army STARRS survey data linked to administrative data. Another noteworthy limitation is that differences between never-deployed and ever-deployed soldiers and differences between soldiers in their first 4 years of service and later years of service cannot be interpreted as evidence of within-person changes in suicide risk, as we know that neither deployment nor attrition from Army service occurs at random (Hoge *et al.* 2006; Warner *et al.* 2011; Ireland *et al.* 2012). In addition, only net associations of predictors were examined controlling other predictors without attempting to trace out indirect pathways of distal predictors through proximal predictors.

Within the context of these limitations, our results replicate and extend previous studies of military suicides in a number of ways.

Sex

Although the higher suicide rate of men than women is well known, no previous research documented variation in this association by deployment status. This specification could be due to deployment-related stressors being higher among women than men, access to firearms increasing more among women than men during deployment, vulnerabilities to stressor effects

increasing during deployment more among women than men, sex-linked differential selection into deployment, or some combination of these processes. The possibilities involving stress have been the subject of considerable speculation in the years since women began to have expanded combat roles (Bond, 2004; La Bash *et al.* 2009; Street *et al.* 2009). Limited empirical research suggests that deployed women might be exposed to more interpersonal stresses than men (Kang *et al.* 2005; Vogt *et al.* 2005, 2011) but that sex differences in adverse psychological effects of deployment-related stresses are insignificant (Vogt *et al.* 2011; Woodhead *et al.* 2012). Policies to increase the combat roles of women heighten the practical importance of examining this specification in more depth in future HADS analyses.

Marital status

Previous studies of military suicide have found, consistent with the HADS finding, that the protective effect of marriage is weaker among soldiers than in the general population (Black *et al.* 2011; Hyman *et al.* 2012; Logan *et al.* 2012) and in civilians (Kposowa, 2000). This result has been interpreted as reflecting unique stresses of military marriages (Drummet *et al.* 2003). However, this cannot be a completely adequate explanation, as available evidence shows that these stresses are more intense among soldiers with than without a history of deployment (Sheppard *et al.* 2010; Harvey *et al.* 2012; Riviere *et al.* 2012), whereas our data show that marriage is associated with low suicide risk among currently deployed enlisted soldiers. More fine-grained analysis of these complex specifications is needed.

Enlistment age

Although previous research found enlistment age unrelated to soldier suicides overall (Gradus *et al.* 2013), our study is the first to examine interactions of enlistment age with deployment status. A plausible interpretation of our finding that early enlistment predicts suicide during deployment is that early enlistment is an indicator of unmeasured vulnerabilities to deployment-related stress, but more fine-grained analysis of this possibility is needed before considering interventions to enhance resilience among soon-to-deploy soldiers with early enlistment age.

Rank and time in service

Although a number of previous studies found inverse associations of suicide with rank (Bell *et al.* 2010; Bachynski *et al.* 2012; Hyman *et al.* 2012) and time in service (Bell *et al.* 2010), none investigated the

conjunction of rank and time in service; this led us to discover high suicide rates among junior enlisted soldiers either deployed during their first year of service or with LTE junior rank. Interventions aimed at these junior enlisted soldiers could be significant, as soldiers in their first year of service account for nearly 15% of all suicides among deployed enlisted soldiers in their first 4 years and soldiers with LTE rank account for 35.3% of all suicides among never-deployed, 24.0% among currently deployed, and 21.7% among previously deployed enlisted soldiers in their first 4 years of service. Although the simple descriptive results presented here provide no insights into the most appropriate preventive interventions for these soldiers, the high PAR values associated with these predictors make them important targets for future analyses of underlying causal processes.

Deployment

As noted in the Introduction, a number of previous studies have documented higher suicide rates among ever-deployed than never-deployed soldiers (Black *et al.* 2011; Thomsen *et al.* 2011; Hyman *et al.* 2012; Bachynski *et al.* 2012). However, those studies examined deployment history in the aggregate rather than with the specifications considered here and consequently failed to document the subgroup variations found here in the associations of deployment history with suicide. These specifications require more in-depth investigation to elucidate their underlying mechanisms. We also noted in the Introduction that speculation exists that multiple deployments (Ritchie, 2012), long deployments (Shen *et al.* 2012) and short dwell times between deployments (MacGregor *et al.* 2012) might be risk factors for suicide, although at least some previous empirical research is inconsistent with these suggestions (Hyman *et al.* 2012; Leard-Mann *et al.* 2013). There is also evidence that multiple deployments are associated with screening positive for post-traumatic stress disorder (PTSD) in post-deployment assessment surveys (Reger *et al.* 2009) and that shorter dwell times are associated with high risk of PTSD and other mental health problems (MacGregor *et al.* 2012). However, we found no evidence for associations of suicide with any of these variables in our analyses.

Implications beyond the US Army

Although the focus of this report was on predictors of suicide among US Army soldiers, Army STARRS results have broader relevance in two ways. First, our findings regarding the associations of sex and marital status with suicide touch on patterns found in the general population (Nock *et al.* 2008). The male:female

suicide ratio in the HADS is roughly comparable with the ratio in the total US population (Rockett *et al.* 2012) despite women making up a much smaller proportion of the Army than the general population. The finding that the male:female suicide ratio varied significantly by deployment documents that the sex difference in suicide is sensitive to environmental experiences, raising the question whether parallel variation exists in the general population. We are unaware of research on this question. However, more focused analysis of the factors underlying this specification in the Army (i.e. changes in sex differences in stress exposure or reactivity during rather than before or after deployment) might provide useful information on the factors underlying sex differences in suicide more generally. Similarly, more in-depth analysis of the fact that the protective effect of marriage emerges only during deployment among US Army personnel might expand our understanding of the ways that marriage protects against suicide more generally.

Second, while most of the predictors in our analysis were defined only for the military, the constructs underlying these predictors have civilian counterparts. This means that our findings might be used to suggest new areas of investigation in studies of the general population. For example, while our measure of LTE junior enlisted rank is unique to the US Army, LTE career advancement exists in the general population and might be a significant predictor of suicide. We are unaware of any previous research on the latter possibility, but our results suggest that this might be an important area of investigation either because low career advancement is a marker of vulnerability or is associated with stressors that lead to suicide. Similarly, future analyses linking the Army STARRS survey data to the HADS might generate more textured results regarding the effects of underlying causal factors that are relevant to suicides in the general population.

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