Technical Report 942

Sampling Weights for the Army Family Research Program (AFRP) Core Research Effort

Vincent G. Iannacchione and Jennifer G. Milne
Research Triangle Institute

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FOREWORD

The Army Family Research Program (AFRP) is a 5-year integrated research program started in November 1986 in response to research mandates in the CSA **White Paper, 1983: The Army Family**. The objective of the research is to (1) determine the demographic characteristics of Army families, (2) identify ways to improve family adaptation to Army life, (3) increase the Army sense of community and partnership, (4) increase family support for retention, and (5) demonstrate family factors that impact upon individual and unit readiness.

This research is being conducted under a Letter of Agreement (LOA) between the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) and the U.S. Army Community and Family Support Center (CFSC) entitled "Sponsorship of ARI Army Family Research." The LOA, dated 18 December 1986, made CFSC the sponsor of the research. The work was done by the Personnel Utilization Technical Area of the Manpower and Personnel Research Laboratory of ARI with the assistance of the Research Triangle Institute, Caliber Associates, the Human Resources Research Organization, and Decision Sciences Consortium, Inc.

The findings from this report were briefed to the Deputy Chief of Staff for Personnel's Military Survey Review Panel and to the AFRP's Scientific Advisory Committee (SAC) in the fall of 1988. Copies of this report have been furnished to members of the SAC and to the sponsor, CFSC.

EDGAR M. JOHNSON
Technical Director

SAMPLING WEIGHTS FOR THE ARMY FAMILY RESEARCH PROGRAM (AFRP) CORE RESEARCH EFFORT

EXECUTIVE SUMMARY

Requirement:

This report describes the computation and use of the sampling weights that appear on the Army Family Research Program (AFRP) data files.

Procedure:

The report summarizes the AFRP sample design, the distribution of AFRP participants, and the scope of the survey population. It includes a discussion of what sampling weights are, why they are needed, and how they should be used. Calculations are provided for adjusting sample weights to compensate for potential nonresponse bias.

Findings:

Because a three-stage hierarchical sample design was used to select the AFRP sample, initial sampling weights were assigned to first-stage sampling units, which correspond to geographic areas; second-stage sampling units, which correspond to Army operational units; and third-stage sample units, which correspond to soldiers and spouses. Adjusted weights were formed by applying adjustment factors to compensate for the potential biasing effects of survey ineligibility and nonresponse to the various AFRP instruments. With the exception of the Spouse Questionnaire, the adjustment factors for nonresponse to AFRP instruments were ratios applied to the initial sampling weights to sum to known population counts. The low participation rate among spouses motivated an adjustment factor based on response probability models.

Utilization of Findings:

The sampling weights described in this report have become part of the AFRP data files and have been used in all AFRP computations and reports. This report is being made available to

our sponsor, the U.S. Army Community and Family Support Center (CFSC), and to project scientists and all others interested in knowing how the sample weights were derived. Proper use of the sampling weights will help to ensure that valid conclusions are drawn from the AFRP data.

SAMPLING WEIGHTS FOR THE ARMY FAMILY RESEARCH PROGRAM (AFRP) CORE RESEARCH EFFORT

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SAMPLING WEIGHTS FOR THE ARMY FAMILY RESEARCH PROGRAM (AFRP) CORE RESEARCH EFFORT

Introduction

Purpose of Report

Sampling weights are indispensable for valid statistical analyses of the data collected by the Army Family Research Program (AFRP). This report describes the computation and use of the sampling weights that appear on the AFRP data files and is intended primarily for analysts who plan to use the AFRP data base for statistical analysis. The report also summarizes the sample design and describes the distribution of AFRP participants and the scope of the survey population from which they were selected.

The sampling weights described here are based on the probability structure that was used to select the sample and should not be confused with other weights that will be used to construct composite measures or indices (e.g., a composite measure of individual readiness).

A basic discussion follows of what sampling weights are, why they are needed, and how they should be used. The report assumes that most readers have little or no experience or training in the design, selection, and analysis of multistage probability samples.

Rationale for Sampling Weights

A survey sample is rarely, if ever, a "scale model" or cross section of the population from which it was drawn. Instead, the combined effects of differential selection and participation rates result in a distribution of survey participants that only distantly resembles that of the survey population. This lack of scale is imposed intentionally at sample selection by the assignment of selection probabilities designed to achieve specific analytic objectives. It is aggravated at data collection by the differential response patterns of the sample members.

Differential selection probabilities were required to achieve the analytic objectives established for the AFRP. For example, officers and married persons, who constitute about 12% and 58% of the survey population, respectively, make up about 29% and 71% of the sample. Without this overrepresentation, much of the inference made to these subpopulations would be inconclusive.

The differential response patterns of sample members cause similar, though less predictable, disproportionalities among survey participants. Consider married officers and their spouses. This group, constituting 14% of the married subpopulation, was oversampled so that it made up 34% of all married sample members. However, the participation rate of spouses of officers was higher than that of any other paygrade group. As a result, over 46% of the spouse participants were spouses of officers. Clearly, without some adjustment of the sample data, estimates for the spouse population would be unduly influenced by this group.

Sampling weights enable unbiased estimation of population parameters by scaling the disproportionalities between a sample and the population from which it was drawn. As such, they may be viewed as inflation factors to account for the number of members in a survey population (e.g., installations, units, or persons) that a sample member represents. Sampling weights are assigned to each sample member and consist of two components: an initial sampling weight and an adjustment factor. The initial sampling weight is simply the inverse of a sample member's selection probability and reflects the different selection rates that were used to select the sample. The adjustment factor is applied to the initial sampling weight to compensate for the potential biasing effects of systematic, nonsampling errors caused by differential nonresponse and sampling frame undercoverage.

The basic component of a sampling weight is the selection probability that is specified by the sample design and assigned to each member of the survey population. The following sections summarize the AFRP sample design and describe the survey population.

Sample Design

The AFRP sample design employed a sampling technique known as multistage, cluster sampling to achieve desired cost savings without negating the inferential capability of the sample. Details of this commonly used statistical procedure are available in standard texts on survey sampling (e.g., Kish, 1965). Three stages of AFRP sample selection were specified by the sample design: installations, units within selected installations, and soldiers (and their spouses) from selected units. Stratification was used at each stage to control the distribution of the samples with respect to organizational and demographic characteristics. These included region of the world at the first stage, unit function at the second stage, and demographic categories defined by paygrade, sex, and marital status at the third stage.

Active-duty Army units, active-duty personnel, and the spouses of those personnel were the primary analytic units planned for the AFRP. However, because Army personnel are stationed in hundreds of locations worldwide, the costs associated with on-site data collection at randomly selected locations would have severely restricted the number of units and persons who could be surveyed. To ensure some control of the geographic distribution of the sample, a sample of geographic locations, each containing one or more Army installations, was drawn with the requirement that the subsequent selection of units be confined to these locations. Further, the selection of soldiers and their spouses was confined to selected units. Approximately equal-sized samples of soldiers were drawn from each unit to facilitate the estimation of unit-specific attributes.

The first-stage sample of 43 first-stage selections from 34 geographic areas was selected in September 1988 with probabilities proportional to a composite size measure based on weighted counts of eligible soldiers assigned to an eligible location. Composite size measures were used to attain, in expectation, the desired second- and third-stage sample allocations for the various subpopulations of interest. Within selected locations, the second-stage sample of 612 units was selected in November 1988 with probabilities proportional to the composite number of persons assigned to eligible units.

Finally, the third-stage sample of 20,033 soldiers and their spouses was selected from 528 participating units between December 1988 and March 1989 with approximately equal probabilities within each third-stage stratum. Because of their importance to the unit-level analyses, the commanders of all selected units were also included in the sample. At each stage, the sample selection probabilities were assigned to sampling units to yield an approximately self-weighting (i.e., equal probability) sample of soldiers and spouses within categories defined by the intersection of unit function and demographic category. The sample design and sample selection activities are described in detail in the AFRP Report on Survey Implementation (RTI, 1990).

Survey Population

Because of the three-stage, hierarchical nature of the sample design, the AFRP survey population is defined in terms of eligible locations at the first stage, eligible units located at eligible locations at the second stage, and eligible soldiers assigned to eligible units and spouses of eligible soldiers at the third stage. Specifically,

- A location was eligible for the survey if at least a thousand active-duty Army personnel were stationed at it or within 50 miles of it in May 1988.

- A unit was eligible if, between sample selection (February 1989 to March 1989) and data collection (February 1989 to October 1989), it was located at an eligible location, was unclassified, had more than 20 active-duty persons assigned to it and was not a transition point (i.e. pipeline) or separation unit, a medical holding or confinement unit, or a unit comprising only trainees or students.

- A soldier was eligible if he or she was:
  1. On active duty and assigned to an eligible unit at the time of sample selection and still assigned to the same unit at data collection,
  2. In paygrade E2 through O6 at the time of sample selection and data collection, and
  3. Not AWOL, hospitalized, incarcerated, or detached from unit at data collection.

- A spouse was eligible if, at the time of data collection, he or she was married to an eligible soldier.

The survey's eligibility requirements were determined by: (a) the research objectives of the survey, (b) the survey's accessibility to Army personnel, and (c) the resources available to the survey. Specifically, the survey was restricted to persons assigned to operational units in order to support the planned unit-level analyses. The additional requirement that eligible units have more than 20 soldiers was necessary to ensure that the unit sample would yield the required number of soldiers and spouses to compute individual-based measures for units.

Army personnel who were stationed more than 50 miles from an installation with a thousand or more soldiers were excluded to control data collection

costs. Although it affected about 5% of all Army personnel, this decision was made with the knowledge that the extent of Army family services available to these persons is likely to be quite different than that available to their eligible counterparts.

A soldier was required to be assigned to the same unit between sample selection and data collection because the Army required that units be notified of personnel selected for the survey at least 60 days prior to data collection. In addition, the Army did not authorize following soldiers beyond the units participating in the survey. Soldiers and spouses who were undergoing or just completing a Permanent Change of Station (PCS) were most affected by this requirement. Army-imposed delays in the start of data collection in Panama, Germany, and several CONUS installations lengthened the time between sample selection and data collection for sample members stationed at these locations. As a result, a greater than expected number of soldiers was excluded from the survey population because of reassignment or separation.

Members of the AFRP survey population were defined by a positive probability of selection into the sample. The size of the survey population was estimated from effective troop strength counts of personnel in paygrades E2 through O6 assigned to nonclassified active duty units (as identified by the UIC, the Unit Identification Code). The counts were provided by the U.S. Army Personnel Command (PERSCOM) for September 1989, the approximate midpoint of data collection. Effective troop strength (which excludes personnel en route, replacements, prisoners, patients, students, and personnel in the process of separating) was used because it corresponds closely with the eligibility requirements for the survey.

As Table 1 indicates, about 91% of the effective troop strength was assigned to the 5,173 units eligible for the survey in September 1989. However, the extended period between sample selection and data collection (over 6 months in a number of cases) meant that, in effect, only persons assigned to the same eligible unit for this length of time had a chance of participating in the survey. This additional eligibility requirement reduced the size of the survey population to an estimated 72% of effective troop strength, or 471,497 soldiers.

Table 1

AFRP Survey Population

	Units		Personnel	
	Count	%	Count	%
Effective troop strength[a]	9,578	100	655,528	100
Units				
Ineligible				
More than 50 miles from a nucleus site[b]	1,655	17.3	36,632	5.6
Twenty or fewer persons[c]	2,750	28.7	20,931	3.2
	3,405	46.0	57,563	8.8
Eligible	5,173	54.0	597,695	91.2
Soldiers in eligible units[d]				
Ineligible				
Reassigned between selection and data collection			86,226	13.2
Left Army between selection and data collection			32,897	5.0
Other			7,075	1.1
			126,198	19.2
Eligible				
Married[e]			278,041	42.4
Nonmarried			193,456	29.6
			471,497	72.0

[a] Army active-duty personnel in paygrades E2 through O6 assigned to non-classified units in September 1989. Effective troop strength excludes personnel en route, replacements, prisoners, patients, students, and personnel in the process of separating.

[b] A nucleus site is defined as an installation, post, or location where a thousand or more active-duty Army personnel were stationed in May 1988.

[c] Units within 50 miles of a nucleus site.

[d] Survey estimates.

[e] All persons married to eligible soldiers at the time of data collection were eligible for the survey.

Computation of Sampling Weights

Overview

Sampling weights were computed via a two-step process. First, initial sampling weights were constructed by assigning the inverse of the selection probability to each sampling unit. Because a three-stage, hierarchical sample design was used to select the AFRP sample, initial sampling weights were assigned to first-stage sampling units (FSUs), which correspond to geographic areas; second-stage sampling units (SSUs), which correspond to Army operational units; and third-stage sampling units (TSUs), which correspond to soldiers and spouses. The selection probabilities used at each of these stages were assigned in accordance with the sample design.

After the initial sampling weights were computed, adjusted weights were formed by applying an adjustment factor to compensate for survey ineligibility and nonresponse to the various AFRP instruments. Without such an adjustment and if nonrespondents' characteristics of interest differed from those of respondents, survey estimates could be biased.

In general, a separate adjustment factor (and hence, adjusted weight) was computed for each source of data. For example, survey estimates based solely on data collected from unit commanders on the Unit Information Form (UIF) required an adjustment factor that compensates for nonresponse to that instrument. Thus, an adjusted sampling weight for data from the UIF was computed by multiplying the initial second-stage (unit level) sampling weight by the adjustment factor for the UIF. Similarly, survey estimates based on data collected from two or more instruments (e.g., a multiple regression model using data from the Soldier Questionnaire and a readiness measure based on supervisory ratings) required a set of adjusted weights that compensate for combined nonresponse to those instruments. The participation status of AFRP units, soldiers, and spouses is shown in Table 2.

With the notable exception of the Spouse Questionnaire, the adjustment factors for nonresponse to AFRP instruments were ratios that were, applied to the initial sampling weights of respondents to force the adjusted weights to sum to known population counts. The low participation rate among spouses motivated an adjustment factor based on response probability models.

The ratio-adjustment procedure is based on the presumption that the weighted distribution of responses of respondents and nonrespondents have the same expected values. This assumption is more plausible when respondents and nonrespondents with similar known characteristics are partitioned into subclasses referred to as post-strata. Thus, a separate ratio adjustment factor was computed within each post-stratum and then applied to each respondent's sampling weight. For most sets of analysis weights described in the following sections, post-strata corresponded to the strata used to select the sample, i.e., region of the world, type of unit, paygrade, marital status, and gender.

Table 2

Participation Summary of AFRP Units, Soldiers, and Spouses

Participation status	Count	Percent: Within groups	Percent: Across groups
Units			
Ineligible:			
All trainees	25	35.7	
Unit moved	16	22.9	
Less than 21 persons assigned	15	21.4	
Other	14	20.1	
	70	100.0	11.4
Eligible:			
Did not participate	14	2.6	
No UIF, at least one Sol Ques	154	28.4	
UIF and at least one Sol Ques	374	69.0	
	542	100.0	88.6
Total units selected	612	100.0	
Soldiers in participating units			
Ineligible:			
Reassigned	4,066	71.8	
Separated	1,309	23.5	
Other	287	5.1	
	5,662	100.0	28.3
Eligible:			
Did not participate[a]	1,174	8.2	
Sold Ques Only	1,376	9.6	
IRR Only	2,162	15.0	
Sold Ques and IRR	9,659	67.2	
	14,371	100.0	71.7
Total soldiers selected	20,033		100.0
Spouses of participating soldiers			
Mailing address not provided	1,669		21.4
Mailing address provided:			
Did not participate	2,846	46.5	
Spouse Ques	3,277	53.5	
	6,123	100.0	78.6
Total spouses selected	7,792		100.0

[a]Includes soldiers who were on temporary duty, leave, or were sick during data collection.

First-Stage Sampling Weights

At the first stage, FSUs (i.e., designated geographic areas) were selected with probabilities proportional to a composite size measure to ensure that the desired unit- and person-level sample sizes were achieved, in expectation. Initially, 40 first-stage selections were made for the primary sample. In addition, 10 alternate selections were made in the event that higher priorities precluded participation by a primary FSU. Computational details of the selection of primary and alternate FSUs are provided in Appendix A.

During data collection, scheduling conflicts resulted in the replacement of three primary selections in CONUS with three alternates also in CONUS. In addition, an alternate FSU in Korea and both alternates in Germany were added to the primary sample. The Seoul FSU in Korea was added at the request of the Eighth Army to provide a more comprehensive understanding of the impact of Army family services on soldiers and their families stationed in Korea. The alternate FSUs in Germany were added in anticipation of response problems caused by an Army-imposed delay in the start of data collection in Germany. These additional FSUs increased the first-stage sample size to 43 selections from 34 local areas. (Multiple selections were made at the eight largest local areas.)

The expected selection frequencies were calculated for each FSU i in first-stage stratum a as follows:

- For FSUs in CONUS, Alaska, and Hawaii (a=1):
$$E[n(i)] = 26 \cdot S'(i) \Big/ \sum_{i \in a} S'(i),$$

- For FSUs in Europe (a=2):
$$E[n(i)] = 14 \cdot S'(i) \Big/ \sum_{i \in a} S'(i),$$

- For FSUs in Japan, Panama, or Korea (except the Seoul FSU) (a=3):
$$E[n(i)] = 2 \cdot S'(i) \Big/ \sum_{i \in a} S'(i),$$

- For the Seoul, S. Korea, FSU:
$$E[n(i)] = 1,$$

where S'(i) = composite size measure assigned to FSU i.

The computational details of the composite size measure assigned to FSUs are presented in Appendix B.

The sampling weight assigned to FSU i is the ratio of the actual selection frequency to the expected selection frequency, i.e.,

$$FSUwt(i) = \frac{n(i)}{E[n(i)]},$$

where n(i) = actual selection frequency of FSU i.

Because a Probability Minimum Replacement (PMR) sample selection algorithm (Chromy, 1979) was used to select the first-stage sample, n(i) was either the integer portion of E[n(i)] or the next largest integer.

Second-Stage Sampling Weights

Initial Soldier Weights. At the second stage, Army operational units served as second-stage sampling units (SSUs). The original second-stage sample comprised 480 primary units and 91 alternate units selected from the 40 first-stage selections. When the first-stage sample was increased to 43 selections, the second-stage sample size was increased to 515 primary units and 97 alternate units.

Initially, the unit replacement strategy called for the activation of an alternate unit whenever a primary unit was found to be ineligible or unavailable for the survey. However, this strategy was changed soon after data collection began, primarily because of the requirement to task units 60 days in advance of data collection. To satisfy this requirement and still maintain a viable set of alternates, it was necessary to schedule alternate units for data collection until the participation status of all units could be determined. The negative implications of cancelling an alternate unit after the tasking of selected individuals, the marginal difference in data collection costs, and a higher than expected ineligibility rate led to the activation of all alternate units selected for the survey.

Two second-stage strata were defined in terms of unit deployability as per the Modified Table of Organization and Equipment (MTOE) and the Table of Distribution and Allowances (TDA). Denoting MTOE units by b=1 and TDA units by b=2, the expected selection frequencies were calculated for each SSU j in second-stage stratum b from selected FSU i in first-stage stratum a as follows

$$E[n(i,j)] = \frac{n_{ab} \cdot S'(i,j)}{\sum_{i \epsilon a} \sum_{j \epsilon b} S'(i,j)},$$

where n_{ab} = number of SSUs in second-stage stratum b selected from first-stage stratum a, and

$S'(i,j)$ = composite size measure assigned to SSU j in FSU i.

The computational details of this composite size measure are provided in Appendix B of the AFRP Report on Survey Implementation.

The initial sampling weight assigned to each SSU j in FSU i was

$$SSUwt(i,j) = \frac{n(i,j)}{E[n(i,j)]} \cdot FSUwt(i),$$

where $n(i,j)$ = actual selection frequency of SSU j in FSU i.

The second-stage sample, like the first-stage sample, was selected with PMR. Thus, $n(i,j)$ was either the integer portion of $E[n(i,j)]$ or the next largest integer.

Adjustments for Unit Nonparticipation. A total of 70 of the 612 units selected for the survey were considered ineligible for reasons shown in Table 2. Personnel assigned to ineligible units are not included in the population of inference. Of the 542 eligible units, 528 provided at least one completed Soldier Questionnaire and were considered participating. Because the 14 eligible but nonparticipating units were undergoing normal operational activities, it is reasonable to assume that the data provided by their responding counterparts are representative of them as well. Thus, a nonresponse adjustment procedure was used to correct for the potentially biasing effects of differential nonparticipation.

Post-stratification adjustments were applied to the initial second-stage sampling weights of participating units so that in each post-stratum, the sum of the adjusted weights equalled the number of eligible units Army wide in September 1989. Ten post-strata were formed by intersecting region of the world with type of unit. (Some collapsing across region and unit type were needed to ensure a stable adjustment factor.)

To adjust for unit nonparticipation, two response indicators were assigned to each eligible SSU j in FSU i. The first indicator identifies the 528 units satisfying minimum participation requirements:

$$\text{SSUrsp}(i,j) = \begin{cases} 1 & \text{if a soldier in SSU j in FSU i provided at least one usable Soldier Questionnaire, and} \\ 0 & \text{otherwise.} \end{cases}$$

The second indicator identifies the 374 units that provided a usable Unit Information Form (UIF):

$$\text{UIFrsp}(i,j) = \begin{cases} 1 & \text{if SSU j in FSU i provided at least one usable Soldier Questionnaire and a usable UIF, and} \\ 0 & \text{otherwise.} \end{cases}$$

Now, let $N_{b'}$ designate the number of eligible units on the September 1989 Personnel Master Files in post-stratum b' where b'=1,2,...,10. Then, the adjustment factor for participating units in post-stratum b' is

$$\text{SSUadj}_{b'} = \frac{N_{b'}}{\sum_{i} \sum_{j \in b'} \text{SSUwt}(i,j) \cdot \text{SSUrsp}(i,j)} .$$

Similarly, the adjustment factor for participating units in post-stratum b' that also provided a UIF is

$$UIFadj_{b'} = \frac{N_{b'}}{\sum_{i} \sum_{j \in b'} SSUwt(i,j) \cdot UIFrsp(i,j)} .$$

Two sets of adjusted unit weights were formed by applying the above adjustment factors to the initial second-stage weight of respondents:

$$SSUadwt(i,j) = SSUwt(i,j) \cdot SSUadj_{b'} \cdot SSUrsp(i,j), \text{ and}$$

$$UIFwt(i,j) = SSUwt(i,j) \cdot UIFadj_{b'} \cdot UIFrsp(i,j).$$

Within each post-stratum, the sum of each set of adjusted weights equals the number of eligible units found on the personnel master files in September 1989. The second-stage post-stratification adjustment factors are summarized in Table 3.

Third-Stage Sampling Weights

Initial Soldier Weights. At the third stage, active-duty soldiers and their spouses served as third-stage sampling units (TSUs). The third-stage soldier sample comprised 20,033 soldiers from the 528 participating units. The spouse sample comprised all spouses of selected soldiers who were eligible for the survey and who provided a usable Soldier Questionnaire. Twenty third-stage strata were formed by the intersection of paygrade group (i.e., E2-E4, E5-E9, W1-W4, O1-O3, and O4-O6), marital status (i.e., married and not married), and gender.

The initial third-stage sampling weight is the product of the adjusted second-stage weight and the inverse of the conditional probability of selecting a soldier within a selected unit. Denoting third-stage strata by c=1,2,...,20, the initial sampling weight assigned to each soldier k in SSU j in FSU i was

$$TSUwt(i,j,k) = SSUadwt(i,j) \cdot \frac{N_c(i,j)}{n_c(i,j)} ,$$

where $N_c(i,j)$ = total number of soldiers in third-stage stratum c in SSU j in FSU i, and

$n_c(i,j)$ = desired sample allocation for third-stage stratum c in SSU j in FSU i.

The initial third-stage sampling weight was assigned to each of the 20,033 soldiers selected for the sample. However, not all of the sample members were eligible for the survey and not all of the eligible sample members participated in the survey. The adjustments for soldier ineligibility and instrument-specific nonresponse are described in the following sections.

Table 3

Second-Stage Post-Stratification Adjustment Factors

Post-stratum (b')	Eligible units: Population[a] ($N_{b'}$)	Eligible units: Sample	Participating units: Sol Ques	Participating units: UIF	Adjustment factors: $SOLadj_{b'}$	Adjustment factors: $UIFadj_{b'}$
Combat						
CONUS	1,310	116	111	86	1.32	1.25
Europe	788	80	80	60	1.11	1.17
Other OCONUS	131	27	25	17	0.58	1.71
	2,229	223	216	163		
Combat support (CS)						
CONUS	443	36	35	25	1.44	1.44
Europe	353	38	38	26	1.00	1.46
	796	74	73	51		
Combat service Support (CSS)						
CONUS	528	46	45	33	1.09	1.31
Europe	405	54	52	34	0.83	1.58
	933	100	97	67		
CS and CSS						
Other OCONUS	173	21	20	12	1.26	1.90
TDA						
CONUS	861	94	93	69	1.43	1.37
OCONUS	181	30	29	12	0.90	1.83
	1,042	124	122	81		
Total	5,173	542	528	374	1.15	1.35

[a] Distribution of eligible units in September 1989.

Adjustments for Soldier Ineligibility. The eligibility status of each selected soldier was maintained on the survey's control system. In general, soldiers were assumed to be eligible unless they were specifically classified as ineligible during the rater assignment process or during data collection. In all, 5,662 soldiers were considered ineligible for reasons shown in Table 2.

The exact number of soldiers eligible for the survey (i.e., the size of the survey population) was difficult, if not impossible, to determine because the eligibility requirements, described in the Introduction had to be applied to every soldier on active duty at data collection. However, the eligibility rates observed for sample members can be applied to Army-wide personnel counts to obtain accurate estimates of the total number of eligible soldiers in various subpopulations or post-strata. The initial third-stage sampling weights were ratio-adjusted to these post-strata estimates as a way of compensating for differential ineligibility among sample members.

The adjustment process began by forming third-stage post-strata on the basis of paygrade, marital status, gender, type of unit, and region of the world. Although 288 post-strata were possible, collapsing across combinations with few or no sample members led to the formation of the 79 post-strata shown in Appendix A. The minimum size requirements were imposed to ensure a stable estimate of the eligibility rate in each post-stratum.

After the post-strata were defined, post-stratum totals were obtained by categorizing each of the 597,695 persons assigned to the 5,173 eligible units on the September 1989 Personnel Master Files. Let $N_{c'}$ denote the total of persons in each post-stratum c' where c'=1,2,...,79.

The eligibility rates observed for sample members in each post-stratum were used to compute the following post-stratified adjusted weight. First, the following eligibility indicator was assigned to each sample member k in SSU j in FSU i:

$$TSUelg(i,j,k) = \begin{cases} 1 & \text{if sample member k in SSU j in FSU i} \\ & \text{was eligible for the survey, and} \\ 0 & \text{otherwise.} \end{cases}$$

Then, the estimated total number of eligible persons in each post-stratum c' is

$$\hat{E}_{c'} = \frac{\sum_i \sum_j \sum_{k \in c'} TSUwt(i,j,k) \cdot TSUelg(i,j,k)}{\sum_i \sum_j \sum_{k \in c'} TSUwt(i,j,k)} \cdot N_{c'} .$$

Finally, the initial third-stage sampling weight was ratio-adjusted so that, within each post-stratum, the sum of the adjusted weights assigned to eligible soldiers equaled the estimated total number of eligible soldiers in the post-stratum:

$$TSUelgwt(i,j,k) = \frac{TSUwt(i,j,k) \bullet TSUelg(i,j,k)}{\sum_i \sum_j \sum_{k \in c'} TSUwt(i,j,k) \bullet TSUelg(i,j,k)} \bullet \hat{E}_{c'} .$$

Nonzero values of this eligibility-adjusted weight were assigned to the 14,371 sample members who were eligible for the survey. In turn, the weight underwent a series of further adjustments to compensate for nonresponse to AFRP instruments.

Adjustments for Soldier Nonresponse. Three separate instruments were administered to eligible soldiers, their supervisors, and their units:

1. The Soldier Questionnaire (SOL) was administered to selected soldiers and is the primary source of data for the Core Research Effort,

2. The Individual Readiness Rating (IRR) was administered to the first- and second-line supervisors of selected soldiers, and

3. The Unit Information Form (UIF) was administered to the units of selected soldiers.

Although these instruments were administered to three different kinds of respondents, each provided information related to selected soldiers. Thus, for analytical purposes, the data from the three sources may be concatenated to form an extended vector of information about each selected soldier.

Each of these providers of information exhibited a distinct response pattern. For example, the participation of a selected soldier had little to do with the participation of his or her first- or second-line supervisor. Similar remarks can be made for the response pattern of units. As a result, varying degrees of incompleteness appear in the vector of information about each soldier.

By considering the three instruments individually, in pairs, or simultaneously, eight response combinations are possible. For example, a survey estimate might be based only on data from the UIF. Or, a multivariate model may be based on data from the SOL and the IRR. However, most of the planned analyses rely on the data provided by the SOL. Thus, nonresponse adjustments were made only for the following response combinations:

1. SOL alone, IRR and UIF not considered;
2. IRR alone, SOL and UIF not considered;
3. SOL and IRR combined, UIF not considered; and
4. SOL and UIF combined, IRR not considered.

Notice that the combinations are not mutually exclusive. For example, a soldier with an SOL and an IRR would be considered a respondent to all but the last combination. This multiplicity motivated the creation of four nonresponse-adjusted weights for each soldier.

The four adjusted weights were computed by applying post-stratification adjustments to the eligibility-adjusted third-stage weight of each soldier. Four response indicators were assigned to each eligible soldier k from unit j in FSU i. The first indicator identified the 11,035 soldiers who provided a usable Soldier Questionnaire:

$$\text{SOLrsp}(i,j,k) = \begin{cases} 1 & \text{if soldier k from unit j in FSU i provided at least one usable Soldier Questionnaire, and} \\ 0 & \text{otherwise.} \end{cases}$$

The second indicator identified the 11,821 soldiers with a non-blank IRR:

$$\text{IRRrsp}(i,j,k) = \begin{cases} 1 & \text{if a non-blank IRR was obtained for soldier k from unit j in FSU i, and} \\ 0 & \text{otherwise.} \end{cases}$$

The third indicator identified the 9,659 soldiers with a usable Soldier Questionnaire and a non-blank IRR:

$$\text{SOLIRRrsp}(i,j,k) = \begin{cases} 1 & \text{if soldier k from unit j in FSU i provided a usable Soldier Questionnaire and for whom a non-blank IRR was obtained, and} \\ 0 & \text{otherwise.} \end{cases}$$

The fourth indicator identified the 8,079 soldiers who have a usable Soldier Questionnaire and a UIF:

$$\text{SOLUIFrsp}(i,j,k) = \begin{cases} 1 & \text{if soldier k from unit j in FSU i provided a usable Soldier Questionnaire and unit j in FSU i provided a useable UIF, and} \\ 0 & \text{otherwise.} \end{cases}$$

The corresponding adjustment factors applied to soldiers in post-stratum c' are

$$\text{SOLadj}_{c'} = \frac{\hat{E}_{c'}}{\sum_i \sum_j \sum_{k \in c'} \text{TSUelgwt}(i,j,k) \cdot \text{SOLrsp}(i,j,k)},$$

$$\text{IRRadj}_{c'} = \frac{\hat{E}_{c'}}{\sum_i \sum_j \sum_{k \in c'} \text{TSUelgwt}(i,j,k) \cdot \text{IRRrsp}(i,j,k)},$$

$$SOLIRRadj_{c'} = \frac{\hat{E}_{c'}}{\sum_i \sum_j \sum_{k \in c'} TSUelgwt(i,j,k) \cdot SOLIRRrsp(i,j,k)} , \text{ and}$$

$$SOLUIFadj_{c'} = \frac{\hat{E}_{c'}}{\sum_i \sum_j \sum_{k \in c'} TSUelgwt(i,j,k) \cdot SOLUIFrsp(i,j,k)} .$$

The four sets of adjusted weights were formed by applying the above adjustment factors to the eligibility-adjusted third-stage weight of respondents:

$$SOLwt(i,j,k) = TSUelgwt(i,j,k) \cdot SOLadj_{c'} \cdot SOLrsp(i,j,k) ,$$

$$IRRwt(i,j,k) = TSUelgwt(i,j,k) \cdot IRRadj_{c'} \cdot IRRrsp(i,j,k) ,$$

$$SOLIRRwt(i,j,k) = TSUelgwt(i,j,k) \cdot SOLIRRadj_{c'} \cdot SOLIRRrsp(i,j,k) , \text{ and}$$

$$SOLUIFwt(i,j,k) = TSUelgwt(i,j,k) \cdot SOLUIFadj_{c'} \cdot SOLUIFrsp(i,j,k) .$$

Within each post-stratum, the sum of each set of adjusted weights equals the estimated total number of eligible soldiers in September 1989. The third-stage post-stratification adjustment factors are summarized in Appendix C.

Spouse Weights. All persons married to eligible selected soldiers at the time of data collection were eligible for the spouse survey. However, soldiers had to agree to their spouses' participation and they provide their spouses' mailing addresses. Accordingly, Spouse Questionnaires were mailed only to the spouses of soldiers who filled out the Spouse Locator Form (SLF) on the back of Soldier Questionnaire. This method of administration resulted in three opportunities for spouse nonresponse:

1. The married soldier did not provide a Soldier Questionnaire;

2. The married soldier provided a Soldier Questionnaire but did not complete the SLF; or

3. An SLF was completed and a Spouse Questionnaire was mailed, but the spouse either did not receive it or did not complete and return it.

Because marital status was a question on the Soldier Questionnaire, the total number of spouses associated with the 14,371 eligible sample soldiers cannot be determined. Of the 11,035 soldiers who provided a usable Soldier Questionnaire, 7,792 indicated they were married at the time of data collection. Thus, the development of spouse sampling weights began with the assignment of the Soldier Questionnaire weight (i.e., SOLwt) of married soldiers to their spouses.

A total of 1,669 married soldiers provided usable Soldier Questionnaires but did not complete the SLF at the back of the instrument. It is unclear why a married soldier would complete all, or at least most, of the Soldier Questionnaire and then not provide his or her spouse's mailing address. Perhaps the soldier did not want to burden his/her spouse. Or, despite confidentiality guarantees, perhaps the soldier did not want the spouse to have any communication with the Army. On the other hand, perhaps the soldier did not see the SLF or perhaps he or she developed respondent fatigue.

In an effort to determine the major reasons for nonresponse to the SLF, a logistic regression model was used to model the probability of a soldier providing a spouse address as a function of the soldier's responses to questions on the Soldier Questionnaire. A logistic regression model was used rather than a linear model for two reasons:

1. The logistic model is less restrictive because the relationship between the the outcome variable and the explanatory variables is not required to be linear, and

2. The predicted response probabilities produced by the model would necessarily range between zero and one.

The ability of the model to predict a valid response probability for each soldier was particularly important because the model was used to implement a response probability weight adjustment procedure developed at RTI (Folsom, 1990). This procedure constrained the logistic coefficients so that, like the post-stratification ratio adjustment, the adjusted weight sums of respondents for specified reporting domains (post-strata) equalled corresponding totals across respondents and nonrespondents.

Reporting domains were specified by answers to questions from the Soldier Questionnaire as well as by demographic variables such as rank, region, and type of unit. For example, one of the significant explanatory variables in the model was a zero-one indicator created from the response to the question: "Is your spouse now living with you at the same location?" Because soldiers answering no (zero) to this question were less likely to provide an address than those who answered yes (one), a disproportionately large number of the spouse addresses obtained were from soldiers living with their spouses. The effect of the weight adjustment procedure was to alleviate this disproportionality by applying a larger adjustment factor to the weights of soldiers not living with their spouses.

Because of the importance of paygrade in virtually all analyses, a hierarchical response model was developed by intersecting all potential explanatory variables with the six paygrade groups. The model was parsed by eliminating any explanatory variables that were not significant at the 0.05 level for at least one paygrade group. The logistic coefficients of the final model were used to compute an expected response probability for each participating soldier. These probabilities were then used to adjust the weights of the 6,123 soldiers who completed the SLF. The mean adjustment factors applied to the soldier weights are shown by paygrade group in Table 4.

An analogous nonresponse adjustment process was used to compensate for spouses who were sent a Spouse Questionnaire but either did not receive it or received it but did not complete and return it. The outcome measure for this response model was a dichotomous variable that was set to one for the 3,277 spouses who provided a usable questionnaire and zero for the 2,846 other spouses. The response probabilities produced by this model were used to adjust the SLF weights of the 3,277 spouse participants. The mean adjustment factors applied to the SLF weights are shown by paygrade group in Table 4.

The development of the final adjusted spouse weight (SPOUWT) is described completely in a separate document (Iannacchione & Milne, 1991).

The final adjusted spouse weight is one of two sampling weights that appear on the spouse data file. SPOUWT is appropriate for analysis based solely on data from the Spouse Questionnaire or for multivariate analysis of data from both the Soldier and Spouse Questionnaires. A second weight (SPREDWT) was developed for multivariate analysis based on data from all three person-level instruments, i.e., the Spouse and Soldier Questionnaires and the IRR.

SPREDWT compensates for combined nonresponse by the soldier, his/her raters, and his/her spouses. The weight was computed by applying post-stratification adjustments shown in Table 5 to SPOUWT within 24 post-strata defined by paygrade group, region, and gender. (Paygrade, region, and gender were found to be significant predictors of combined nonresponse.) Nonzero values of this weight were assigned to the 2,714 soldiers and their spouses for whom a usable Spouse and Soldier Questionnaire and an individual readiness measure were obtained.

Table 4

Spouse Participation Summary

Paygrade	Eligible spouses		Spouse Locator Form		Spouse Questionnaire	
	Population[a]	Sample[b]	Completed forms	Mean adj. factor[c]	Completed ques.	Mean adj. factor[d]
E2-E4	83,113	2,690	2,113	1.28	826	2.69
E5-E6	109,998	1,750	1,315	1.32	613	2.10
E7-E9	38,970	524	397	1.31	226	1.75
W1-W4	8,202	170	124	1.35	87	1.47
01-03	19,799	1,345	1,111	1.21	752	1.51
04-06	17,959	1,313	1,063	1.22	773	1.37
Overall	278,041	7,792	6,123	1.30	3,277	2.02

[a] Survey estimates.

[b] Spouses of soldiers who provided a usable Soldier Questionnaire.

[c] Adjustment factor applied to the adjusted weight of married soldiers who provided a usable Soldier Questionnaire.

[d] Adjustment factor applied to the adjusted weight of married soldiers who completed a Spouse Locator Form.

Table 5

Combined Spouse Questionnaire and Soldier Readiness Rating Post-Stratification Adjustment Factors

Post-stratum Paygrade	Gender	Region	Number of Spouse Ques.	Number of Spouse Ques. and Readiness Ratings	Adjustment factor
E2-E4	M	CONUS	490	438	1.12
	F	CONUS	32	29	1.07
	M	Europe	200	175	1.12
	F	OCONUS	23	21	1.06
	M	Other OCONUS	81	74	1.09
			826	737	1.11
E5-E6	M	CONUS	335	313	1.07
	F	CONUS	36	35	1.02
	M	Europe	164	151	1.07
	F	OCONUS	29	25	1.14
	M	Other OCONUS	49	45	1.05
			613	569	1.07
E7-E9	M	CONUS	133	124	1.06
*	M&F	CONUS & Europe	71	59	1.27
**	M&F	OCONUS	22	21	1.03
			226	204	1.11
W1-W4	M&F	CONUS	47	42	1.09
	M&F	OCONUS	40	35	1.18
			87	77	1.12
O1-O3	M	CONUS	455	394	1.15
	F	CONUS	45	38	1.13
	M	Europe	162	133	1.20
	F	OCONUS	27	22	1.20
	M	Other OCONUS	63	52	1.20
			757	639	1.16
O4-O6	M	Europe	496	326	1.49
	F	All	37	30	1.26
	M	Europe	151	72	2.17
	M	Other	89	60	1.56
			773	488	1.56
Overall			3,277	2,714	1.12

* This post-stratum includes females in CONUS and males in Europe in paygrades E7 through E9.

** This post-stratum includes females in Europe and all others in Other OCONUS in paygrades E7 through E9.

Use of Sampling Weights

Determining Correct Set of Weights for Analysis

Analysts who plan to use the AFRP data files for statistical analysis should determine which set of sampling weights described is appropriate for their planned analysis. In general, the correct set of weights can be determined by checking the source of the data to be analyzed. For example, the soldier data file contains three sampling weights: SOLWT, SOLIRRWT, and SOLUIFWT. If an estimate is based solely on data from the Soldier Questionnaire, SOLWT is the appropriate weight. However, if data from the Soldier Questionnaire are used to predict individual readiness in a multiple regression model, then SOLIRRWT, the weight that compensates for combined nonresponse to both instruments, is needed. The sampling weights on the AFRP data files are listed in Table 6.

Aggregating Data

In addition to estimating characteristics of the soldier population, data collected at the soldier level can be used to estimate various unit characteristics. For example, data from the IRRs of sample members belonging to the same unit can be averaged to estimate the mean level of individual readiness for the unit. Similarly, the reenlistment propensity of a unit may be estimated by averaging the reenlistment intentions of its sample members. In general, if these characteristics are means or proportions, the appropriate soldier-level sampling weight can be used to properly aggregate the soldier data to the unit level. However, if a unit-specific total is desired, an inflation factor must be applied to account for the wide variation in the sizes of units.

After the individual unit estimates are made, the appropriate unit-level analysis weight should be used for estimation across units. However, because such estimates have a within-unit variance component as well as an among-unit component, estimating sampling errors becomes much more difficult. Within-unit measurement error is especially problematic when unit characteristics are estimated from soldier data and then used as explanatory variables for multiple regressions done at the unit level. This is because most types of regression analysis assume that there is no measurement error associated with the explanatory variables in the model.

Variance Estimation

The samples of installations, units, and persons selected for the AFRP are not simple random samples. Instead, the samples were drawn using a complex, stratified, multistage sample design. Although such sample designs allow for economical data collection, they complicate data analysis because most standard statistical analysis packages implicitly assume simple random sampling from an infinite population. With this in mind, analysts using the AFRP data should be aware that variance estimates that do not account for the sample design may seriously underestimate the true variance. Furthermore, simply providing a sampling weight to a standard analysis package (e.g., SAS Proc Reg with a Weight statement) will not alleviate the problem.

Table 6

Sampling Weights on the AFRP Data Files

Label	Data source(s)	Number of nonzero weights	Sum of[a] weights
Unit level			
SSUADWT	Soldier or spouse data aggregated to units	528	5,173
UIFWT	Unit Information Form	374	5,173
Soldier level			
SOLWT	Soldier Questionnaire	11,035	471,492
IRRWT	Individual Readiness Measure (IRR)	11,821	471,492
SOLIRRWT	Sol Ques AND IRR	9,659	471,492
SOLUIFWT	Sol Ques AND UIF of soldier's unit	8,079	471,492
Spouse level			
SPOUWT	Spouse Questionnaire, or Spou Ques AND Sol Ques	3,277	278,018
SPREDWT	Spou Ques AND IRR, or Spou Ques AND Sol Ques AND IRR	2,714	278,018

[a]The sum of the weights estimates the size of the eligible population.

Taylor series approximation, balanced repeated replications (brr), and jackknife variance estimation (Cochran, 1977) are three well-known techniques that have been developed to provide relatively unbiased methods for estimating the variances of descriptive statistics and regression coefficients from a complex survey. Although each of these methods produces similar results, the Taylor series technique is used in the RTI-developed software and is described here.

The Taylor series approach to variance estimation is based on a first-order Taylor series approximation of the deviations of estimates from their expected values. Woodruff (1971) presents applications of this technique to sample surveys that provide one of the best known numerical approximations for ratio estimates currently available in the statistical literature. The SUDAAN Procedures for Descriptive Statistics (Shah, 1989) developed by RTI compute means, proportions, ratios, cross-tabulations, quantiles, as well as linear and logistic regression coefficients using the Taylor series approximation. In addition, options are available for producing estimates of domain differences and other linear contrasts. SUDAAN is written in the C programming language and will run on any IBM PC compatible system with 640 K memory or on the VAX/VMS systems.

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APPENDIX A: Selection of Primary and Alternate First-Stage Sampling Units

The selection of n_p primary and n_a alternate first-stage sampling units (FSUs) was made with the requirements that 1) the expected selection frequencies be proportional to the composite size measure, and 2) that each self-representing FSU appear in the primary sample. A three-step selection procedure was used to satisfy these requirements:

1) Self-representing FSUs were systematically included in the primary sample I_p times with the number of selections determined by the integer portion of their expected selection frequency;

2) The remaining $(n_p+n_a-I_p)$ first-stage selections were made by selecting a PPS sample with the fractional portion of each FSU's expected selection frequency (self-representers included) serving as the size measure;

3) The remaining (n_p-I_p) primary selections were randomly designated from the selections made in Step 2.

Because the actual selection frequencies in Steps 2 and 3 can differ from their expected counterparts by at most one, the actual overall selection frequency of a unit selected into the primary sample can differ from its expected value by as much as two.

To prove that this procedure attains the desired result, denote the desired expected selection frequency for FSU i by

$$E[n_i] = n_p \cdot S'(i) \; / \; \Sigma \, S'(i),$$

where $S'(i)$ = the composite size measure assigned to FSU i.

This can be rewritten as

$$E[n_i] = I_i + F_i,$$

where $I_i = INT(E[n_i])$,
and $F_i = FRAC(E[n_i])$.

Also, let

$$I_p = \Sigma\, I_i,$$
$$\text{and } F_p = \Sigma\, F_i.$$

This implies that

$$n_p = I_p + F_p.$$

Initially, I_p selections are made by including each FSU i in the primary sample I_i times. The expected value of these selections is

$$E[I_i] = I_i.$$

Then, $n_p+n_a-I_p$ selections are made with probabilities proportional to F_i. Finally, the n_p-I_p primary designations are made randomly with equal probabilities. The expected selection frequency for these primary selections is

$$E[F_i] = \frac{(n_p + n_a - I_p) \cdot F_i}{F_p} \cdot \frac{(n_p - I_p)}{(n_p + n_a - I_p)}$$

$$= F_i .$$

Thus, the overall expected selection frequency for an FSU i is

$$E[n_i] = E[I_i] + E[F_i]$$
$$I_i + F_i .$$

APPENDIX B: Composite Size Measures

Composite size measures were used at the first and second-stages of sample selection to insure that the targeted sample sizes were achieved, in expectation, for the subpopulations of interest, (i.e. the third-stage strata). The composite size measures were formulated in the following manner. Let c = 1,2,...,20 index the subpopulations of interest and let n_c designate the desired sample size for subpopulation c. Further, define $N_c(i,j)$ as the number of eligible soldiers in unit j of FSU i that belong to subpopulation c. Now define the following person-level population counts:

$$N_c(i) = \sum_j N_c(i,j), \text{ and,}$$

$$N_c = \sum_i \sum_j N_c(i,j).$$

Thus, the desired sampling rate for members of subpopulation c is

$$f_c = n_c / N_c.$$

If all units in the population were to be sampled, the sample size of individuals to be selected from subpopulation c in each unit j of FSU i would be

$$n_c(i,j) = f_c \cdot N_c(i,j).$$

This quantity is the basis for the second-stage composite size measure

$$S(i,j) = \sum_c f_c \cdot N_c(i,j),$$

which may be considered the sample size that would be obtained from unit j of FSU i if all the SSUs in the population were sampled with the specified sampling rates of f_c for the individual subpopulations. The population total of this size measure is

$$S = \sum_i \sum_j S(i,j)$$

$$= \sum_c f_c \cdot N_c$$

$$= \sum_{c} n_c ,$$

which is the total third-stage sample size.

The population totals by type of unit are

$$S(MTOE) = \sum_{i} \sum_{j \epsilon MTOE} S(i,j), \text{ and}$$

$$S(TDA) = \sum_{i} \sum_{j \epsilon TDA} S(i,j) .$$

The proportion of MTOE units in the 480 unit sample was changed by applying the multiplicative factors, f(MTOE), to the composite size measure of each MTOE unit, and f(TDA), to the composite size measure of each TDA unit.

The second-stage sample allocations to the MTOE and TDA strata were then expressed as

$$n(MTOE) = \frac{f(MTOE) \cdot S(MTOE)}{S} \cdot 480,$$

rounded to the nearest integer, and,

$$n(TDA) = 480 - n(MTOE).$$

Thus, for a desired allocation of n(MTOE) units, the multiplicative factors are

$$f(MTOE) = \frac{n(MTOE) \cdot S}{S(MTOE) \cdot 480} , \text{ and}$$

$$f(TDA) = \frac{n(TDA) \cdot S}{S(TDA) \cdot 480} .$$

The adjusted composite size measure assigned to unit j of FSU i is

$$S'(i,j) = f(MTOE) \cdot S(i,j), \text{ if } j \epsilon MTOE,$$

and $$S'(i,j) = f(TDA) \cdot S(i,j), \text{ if } j \epsilon TDA.$$

Similarly, the adjusted composite measure assigned to an FSU i is

$$S'(i) = \sum_j S'(i,j).$$

First-stage stratum allocations were made proportional to the sum of the adjusted composite size measures.

An average of 38 eligible soldiers were selected from each selected unit. Each of these samples was allocated to the subpopulations using the adjusted composite size measure assigned to the SSU. The desired allocation to subpopulation c for unit j in FSU i is

$$n_c(i,j) = 38 \cdot f_c \cdot f(\text{MTOE}) \cdot N_c(i,j) / S'(i,j), \text{ if } j \epsilon \text{MTOE},$$

and

$$n_c(i,j) = 38 \cdot f_c \cdot f(\text{TDA}) \cdot N_c(i,j) / S'(i,j), \text{ if } j \epsilon \text{TDA}.$$

The desired sampling rate, or third-stage selection probability, for each member of subpopulation c in unit j of FSU i is

$$f_c(i,j) = 38 \cdot f_c / S(i,j).$$

The expected sample size for a subpopulation c for a randomly selected SSU j within any randomly selected FSU i can be shown to be

$$E[n_c(i,j)] = f_c \cdot N_c(i,j).$$

Similarly, the expected total sample size for a subpopulation c is

$$\begin{aligned} E[n_c] &= E[\sum_i \sum_j n_c(i,j)] \\ &= \sum_i \sum_j f_c \cdot N_c(i,j) \\ &= f_c \cdot N_c \end{aligned}$$

Thus, the desired sampled sample size, n_c, is achieved for subpopulation c in expectation, or on the average over all possible samples generated by the sample design.

Appendix C: Third-Stage Post-Stratification Adjustment Factors

Post-Stratum					Eligible Soldiers		Respondents				Adjustment Factors			
Pay grade	Mar. Stat.	Gender	Type of Unit	Region	Pop.	Samp.	Sold	IRR	Sold-IRR	Sold-UIF	Sold	IRR	Sold-IRR	Sold-UIF
E2-E4	NM	M	C	CONUS	45,473	672	545	614	518	441	1.25	1.10	1.31	1.54
			C	Europe	22,745	348	270	315	258	218	1.33	1.14	1.41	1.64
			C	Other	3,226	131	95	113	84	81	1.38	1.56	1.56	1.58
			CS	CONUS	14,895	214	159	173	142	97	1.38	1.24	1.54	2.24
			CS	Europe	10,178	179	147	167	141	116	1.23	1.08	1.28	1.52
			CS	Other	2,007	32	23	23	21	19	1.41	1.44	1.59	1.67
			CSS	CONUS	11,740	198	148	176	142	92	1.38	1.13	1.43	2.25
			CSS	Europe	7,513	153	101	123	96	65	1.53	1.25	1.60	2.36
			CSS	Other	1,363	53	39	40	37	30	1.34	1.30	1.40	1.76
			TDA	--	8,987	188	164	173	158	122	1.15	1.08	1.19	1.53
		F	C	--	2,382	43	34	36	30	19	1.32	1.22	1.52	2.28
			CS	--	3,691	82	65	73	62	44	1.28	1.12	1.34	1.78
			CSS	--	7,241	174	136	157	126	96	1.34	1.12	1.45	1.89
			TDA	--	3,699	106	93	90	82	61	1.17	1.17	1.32	1.71
	M	M	C	CONUS	21,419	862	695	783	657	566	1.23	1.10	1.30	1.52
			C	Europe	11,152	437	352	389	335	289	1.24	1.14	1.30	1.48
			C	Other	1,485	142	104	118	91	89	1.31	1.20	1.51	1.53
			CS	CONUS	8,372	275	218	238	202	148	1.24	1.15	1.34	1.80
			CS	Europe	5,579	226	179	208	172	132	1.21	1.07	1.24	1.60
			CS	Other	714	44	30	33	28	24	1.45	1.33	1.55	1.81
			CSS	CONUS	8,840	328	246	294	228	169	1.33	1.11	1.45	1.97
			CSS	Europe	5,751	252	200	217	179	110	1.26	1.16	1.40	2.31
			CSS	Other	815	86	56	62	54	43	1.43	1.30	1.47	1.94
			TDA	--	7,578	324	263	278	232	167	1.24	1.14	1.38	1.94
		F	C	--	1,458	52	37	43	33	27	1.37	1.18	1.53	1.85
			CS	--	1,998	63	50	54	45	41	1.27	1.20	1.44	1.51
			CSS	--	4,598	178	144	154	128	97	1.23	1.15	1.38	1.80
			TDA	--	3,354	145	116	130	105	84	1.28	1.11	1.40	1.75
Overall E2-E4					228,253	5,987	4,709	5,274	4,386	3,487	1.27	1.14	1.37	1.72

(continued)

Third-Stage Post-Stratification Adjustment Factors

Post-Stratum					Eligible Soldiers		Respondents				Adjustment Factors			
Pay grade	Mar. Stat.	Gender	Type of Unit	Region	Pop.	Samp.	Sold	IRR	Sold-IRR	Sold-UIF	Sold	IRR	Sold-IRR	Sold-UIF
E5-E6	NM	M	C	CONUS	7,074	133	104	119	95	81	1.27	1.11	1.39	1.62
			C	--	4,271	136	98	122	92	75	1.41	1.09	1.48	1.83
			CS	CONUS	2,404	53	34	41	30	29	1.56	1.31	1.77	1.83
			CS	--	2,062	54	42	51	41	35	1.29	1.06	1.31	1.54
			CSS	CONUS	2,112	41	27	35	24	17	1.48	1.16	1.66	2.37
			CSS	--	1,679	46	36	40	33	29	1.31	1.13	1.38	1.63
			TDA	--	4,559	117	92	99	85	65	1.21	1.15	1.30	1.71
		F	--	--	2,839	66	57	58	52	40	1.19	1.23	1.37	1.67
		F	TDA	--	2,037	51	46	47	42	34	1.10	1.07	1.19	1.50
	M	M	C	CONUS	24,948	451	334	407	318	267	1.31	1.10	1.37	1.64
			C	Europe	14,943	327	255	291	245	204	1.29	1.13	1.33	1.62
			C	Other	1,917	85	57	72	53	45	1.40	1.16	1.49	1.75
			CS	CONUS	8,561	141	93	104	81	61	1.46	1.32	1.69	2.21
			CS	--	8,670	197	140	170	133	109	1.35	1.13	1.41	1.65
			CSS	CONUS	8,856	159	123	144	119	91	1.26	1.09	1.30	1.73
			CSS	--	8,232	237	161	202	149	106	1.45	1.16	1.55	2.19
			TDA	CONUS	21,067	350	267	313	244	219	1.31	1.11	1.42	1.63
			TDA	--	3,445	124	83	100	72	21	1.69	1.23	1.95	3.69
		F	--	--	5,651	182	129	155	119	112	1.32	1.16	1.47	1.98
		F	TDA	--	3,709	138	108	127	101	71	1.30	1.09	1.39	1.90
Overall	E5-E6				139,036	3,088	2,286	2,697	2,128	1,711	1.35	1.14	1.45	1.80
E7-E9	NM	--	--	--	4,629	111	93	98	86	70	1.18	1.13	1.27	1.58
	M	M	C	CONUS	7,665	105	74	85	62	60	1.41	1.23	1.68	1.74
			C	Europe	3,763	66	47	51	40	38	1.43	1.35	1.76	1.74
			C	Other	880	31	25	27	23	18	1.23	1.15	1.34	1.65
			CS	CONUS	2,296	35	29	31	27	23	1.21	1.13	1.31	1.54
			CS	--	2,022	44	32	35	26	17	1.41	1.22	1.68	2.44
			CSS	CONUS	2,967	34	26	29	25	17	1.34	1.19	1.39	2.05
			CSS	--	3,068	74	54	58	45	34	1.34	1.27	1.59	2.03
			TDA	CONUS	14,105	210	162	184	148	129	1.31	1.14	1.43	1.62
			TDA	--	1,304	45	42	34	31	19	1.07	1.34	1.45	2.37
		F	--	--	1,205	46	33	38	30	30	1.45	1.21	1.57	1.83
Overall	E7-E9				43,904	801	617	670	543	448	1.30	1.20	1.48	1.79

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Third-Stage Post-Stratification Adjustment Factors

Post-Stratum					Eligible Soldiers		Respondents				Adjustment Factors			
Pay grade	Mar. Stat.	Gender	Type of Unit	Region	Pop.	Samp.	Sold	IRR	Sold-IRR	Sold-UIF	Sold	IRR	Sold-IRR	Sold-UIF
W1-W4	NM	--	--	--	1,287	62	41	50	37	30	1.33	1.20	1.51	1.43
↓	M	--	--	--	8,202	260	170	179	148	112	1.35	1.27	1.55	2.05
Overall	W1-W4				9,489	292	211	229	185	149	1.38	1.28	1.58	1.96
01-03	NM	M	C	--	4,209	229	180	180	150	145	1.25	1.25	1.48	1.58
|	|	|	CS	--	1,255	60	49	41	36	39	1.26	1.43	1.66	1.56
|	|	|	CSS	--	955	58	46	36	31	30	1.23	1.57	1.82	2.14
|	|	↓	TDA	--	1,819	88	69	68	58	49	1.27	1.30	1.51	1.79
|	↓	F	--	--	2,718	61	53	55	50	46	1.14	1.05	1.16	1.42
|	M	M	C	--	6,595	646	479	500	403	386	1.33	1.26	1.55	1.63
|	|	|	CS	--	1,854	160	119	117	96	91	1.41	1.38	1.71	1.82
|	|	|	CSS	--	2,087	215	168	159	139	130	1.29	1.32	1.55	1.76
|	|	↓	TDA	--	6,552	537	416	441	353	279	1.31	1.19	1.52	1.99
|	|	F	--	--	1,084	104	79	82	64	64	1.30	1.20	1.51	1.60
↓	↓	F	TDA	--	1,627	106	84	91	73	56	1.39	1.14	1.59	2.23
Overall	01-03				30,755	2,264	1,742	1,770	1,453	1,315	1.30	1.28	1.56	1.72
04-06	NM	M	--	--	1,389	135	103	86	75	55	1.31	1.61	1.84	2.37
|	↓	F	--	--	712	61	54	54	50	41	1.11	1.11	1.19	1.58
|	M	M	C	--	2,702	277	201	155	121	147	1.36	1.81	2.28	1.83
|	|	|	CS	--	553	49	33	28	21	23	1.41	1.66	2.09	1.80
|	|	|	CSS	--	1,361	134	103	94	76	92	1.30	1.40	1.72	1.48
|	|	↓	TDA	--	12,139	1,189	904	688	561	557	1.30	1.70	2.08	1.98
↓	↓	F	--	--	1,204	94	72	76	60	54	1.34	1.25	1.65	1.80
Overall	04-06				20,060	1,939	1,470	1,181	964	969	1.32	1.64	2.01	2.00
All Paygrades					471,497	14,371	11,035	11,821	9,659	8,079	1.30	1.22	1.49	1.78