

## Designing Longitudinal Studies of Mobile Populations Such As Military Populations

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### Abstract

This discussion summarizes an exhaustive literature review of research focused on designing sample surveys to accommodate repeated measurements on mobile populations. Attention is given to practical survey design features that lead to improvements in survey response rates from the baseline of data collection through subsequent periods of data collection. Although the authors restricted their literature review primarily to studies involving military populations, similar survey methodology may be adapted to studying other populations as well. In many instances, recommendations and solutions for improving response rates will be presented to address these challenges in surveying mobile populations. Our discussion highlights practical design features from many military studies and important design issues and challenges typically experienced.

### 1. Introduction

Researchers are constantly faced with challenges in designing sample surveys that satisfy the substantive objectives while maximizing respondent participation. With an increase in measures to block unsolicited communication from commercial vendors, securing participation for volunteer studies is becoming more difficult. Consequently, we have seen survey response rates decrease over the last several years. This has increased the potential for survey estimates to be biased due to increases in survey nonresponse (Cochran 1977, Kish 1995). The impact can be substantial for studies involving repeated measures on the same sampling units or longitudinal studies.

An apparent objective of military sample surveys as well as other surveys is the production of estimates that are unbiased for all survey estimators. However, if researchers are confronted with samples partitioned into two distinct subsets consisting of respondents and nonrespondents, then the defensibility of all survey estimates may be in question. The defense rest on whether the respondent sample is representative of the nonrespondent sample. If the respondent sample is in fact representative, then data from the respondent sample will suffice for the balance of the sample. However, if the respondent sample is not representative, then it will be necessary to make adjustments to the design-based weights of the respondents in an effort to correct for the nonresponse bias. For clarification, the nonresponse bias

of a sample mean ( $\bar{x}_R$ ) based on the respondent sample only, is the difference between the estimator and the population mean ( $\mu$ ) if everyone responded from the target population. Hence, the nonresponse bias is:

$$B(\bar{x}_R) = \bar{x}_R - \mu.$$

It follows that the nonresponse bias in  $\bar{x}_R$  can be estimated by:

$$\hat{B}(\bar{x}_R) = \bar{x}_R - \hat{\mu}.$$

Hence, an estimator of the population mean is a function of the following respondent and nonrespondent sample means in a sample survey:

$$\hat{\mu} = (1 - \hat{\eta}) \bar{x}_R + \hat{\eta} \bar{x}_M,$$

given  $\hat{\eta}$  is the weighted nonresponse rate from the design-based weights,  $\bar{x}_M$  is the sample mean based only on the nonrespondent component of the sample. Therefore the bias in  $\bar{x}_R$  can then be estimated by:

$$\hat{B}(\bar{x}_R) = \bar{x}_R - [(1 - \hat{\eta}) \bar{x}_R + \hat{\eta} \bar{x}_M] = \hat{\eta} (\bar{x}_R - \bar{x}_M),$$

Cochran, 1977.

It follows that the bias estimator is the product of the weighted nonresponse rate times an expression of the difference between the mean of the respondents and the nonrespondents based on the design-based weights, which excludes adjustments from nonresponse and poststratification. As the response rate increases, the nonresponse rate decreases or approaches zero. Obviously, there is no bias in the presence of complete response, or when both the respondents and the nonrespondents have identical means. Therefore, the application of sound survey methodology is essential to maximize response rates while simultaneously yielding a respondent sample representative of those that failed to respond.

Longitudinal studies provide information based on measurements of the same individuals at different points in time allowing researchers to monitor changes at the individual level. In contrast, repeated cross-sectional studies use data collected from a different sample of individuals at each point in time. However, cross-sectional studies do not provide any information about how individuals change over time. Furthermore, longitudinal studies have more statistical power than cross-sectional studies because of the correlation between repeated measurements at the individual level. For example, a longitudinal study with a sample size of 550 subjects provides a power of 80% for detecting a

difference between prevalence rates of 5% when the prevalence rates are around 20% and the correlation is 0.5. For a cross-sectional study, under the same assumptions, the power for detecting the same difference (5%) will be only 52%.

The importance of longitudinal studies for military populations are paramount to evaluate the long-term health effects of military service and assess the perceptions and attitudes about various aspects of military life over time. The majority of military studies prove to be repeated cross-sectional studies. Apparently, the primary reason appears to be that military personnel are often transferred to new locations, thus making it difficult to follow them over subsequent data collection periods. For example, a longitudinal study on posttraumatic stress disorder (PTSD) in Gulf War Veterans by Benotsch, et al. (2000), had a sample of 828 veterans in the study at baseline. For the follow-up study, the sample was reduced by as much as 58% attrition to 348 participants. This rate was a result of reservists leaving the military, transferring to another unit, or absent from drill on the scheduled retest date.

Mail surveys are the primary data collection mode for many military studies. However, response rates have declined in the past ten years. For example, the response rate of the Navy Personnel Survey (NPS), from the period 1990 to 2000 dropped from 52% to 33% (Newell et al., 2004). Similarly, in the Navy Equal Opportunity/Sexual Harassment Survey (NEOSH) the response rate dropped from 60% in 1989 to 30% in 1999 (Knouse, 2003). Furthermore, the costs associated with these surveys have increased due to the larger samples and follow-up mailings needed. Therefore, alternative data collection and sampling techniques have been explored.

## 2. Sampling Frames

Given the definition of a sampling frame, which is a list or mechanism used to enumerate population elements for sample selection purposes, we are now faced with the task of locating or constructing the sampling frame. No doubt the process is simplified if the target population is entirely specified on an electronic database. Fortunately, for many military studies, this information can be extracted from databases, such as:

- 1) The Defense Manpower Data Center's (DMDC's) file ([www.dmdc.osd.mil](http://www.dmdc.osd.mil)),
- 2) The Active Duty Master File (ADMF),
- 3) The Reserve Components Common Personnel Data System (RCCPDS) file, and
- 4) The Defense Enrollment Eligibility Reporting System (DEERS) file ([www.dmdc.osd.mil/appj/deerswebsite/home.do](http://www.dmdc.osd.mil/appj/deerswebsite/home.do)), which includes over 23 million records pertaining to active duty and reserve military and their family members, military

retired, DoD civil service personnel, and DoD contractors.

Some studies that use these databases for frame construction purposes are:

- 1) The Department of Defense Survey of Health-Related Behaviors Among Military Personnel ([www.dodwww.rti.org](http://www.dodwww.rti.org)),
- 2) The 1995 Armed Forces Equal Opportunity Survey,
- 3) The 1996 Armed Forces Sexual Harassment Survey, and
- 4) The 1992 Reserve Components Surveys.

These electronic databases provide the information for defining strata and sample size determination/allocation. In addition, the Department of Defense Center for Deployment Health Research has access to military databases with supplemental medical and administrative information used to enhance the survey data (Gray, 2002).

In the absence of an electronic database, researchers may be faced with having to develop a virtual sampling frame from surrogate units. For example, this was the case for the Junior Military Personnel study. Survey objectives required that baseline data collection had to occur immediately after basic military training, or between basic training and advanced training. Hence, the timing of the baseline was very important. Therefore, the electronic databases described above could not be used because of the lag time between the completion of basic training and when this information occurs on the database, or when the information becomes available for researchers. For these situations, it may be necessary to construct a sampling frame of virtual units based on total personnel counts, provided the demographics needed for stratification are available. If the demographic information is available for the population being surveyed, then what remains is to complete the creation of the design strata and to select the probability samples. Due to the fact that these research studies can be very disruptive for the schedules of military personnel, it is often better to administer a census of all eligible personnel in the population at the sample military bases. The underlying assumptions are that 1) cost implications from conducting a census can be ignored, 2) all eligible personnel at the baseline have a non-zero probability of participating in the study, and 3) the participating sample is an unbiased representation of the target population. This would imply that personnel who did not show up, or who did not participate would be treated as eligible non-respondents.

Below, is another example where it was more operationally efficient to conduct a census of all sampling units, or to include all sampling units in the study with certainty. The government of Norway conducted a census from medical examinations of all men born in 1932 and 1933 who were called for conscription for compulsory

military service at the age of 19. This was a 40-year longitudinal study, primarily to assess the risk of premature deaths in alcohol abusers (Rossow and Amundsen, 1997). A total of 33,224 personnel received medical examinations at conscription (in 1951 and 1952) and followed for 40 years or until death. Data on alcohol treatment (if any) were followed and these data were linked by an 11-digit identifier to the Norwegian national death register.

### 3. Data Collection

Recently, Web based surveys have been used as an option to encourage participation in the military population. The Millennium Cohort Study launched in 2001, follows the health of approximately 140,000 service members for up to 21 years. In this study the participants have the option of completing the study questionnaire either on the paper copy received in the mail or through the Web site version (Gray et al., 2002). This is one of the first military studies to implement a mixed-mode Web site design. Participants who complete the survey on the Web site are offered a free gift as an incentive (t-shirts, magnets or a 60-minute phone card) because there are significant cost savings associated with online participation. Edwards and others (1996) showed that responses obtained on computer-administered versus paper surveys were often identical. However, additional research is needed to compare responses from Web site based surveys versus mail based surveys in this type of population because techniques tested to increase response rates in mail surveys may not apply to Web site based surveys.

Common survey methodology employed to address low response rates include conducting follow-up studies of nonrespondents, such as the follow-up study on the 1999 NIOSH Survey sample (Newell et al., 2004). The study indicated that among the reasons why Navy surveys were not returned consisted of the belief that they had no impact, general apathy toward surveys and the length of the questionnaire. Suggestions to increase response rates were to provide feedback to the participants, shortening the length of the questionnaire and provide incentives. Some of these recommendations were implemented in the Millennium Cohort Study Web site ([www.MillenniumCohort.org](http://www.MillenniumCohort.org)), by providing updates on the study progress and the findings to participants and the general public. This Web site is a relatively inexpensive way of keeping participants involved while maintaining communication with research staff members to ask questions or to offer suggestions.

Major challenges in conducting longitudinal studies include maximizing participation at enrollment, maintaining respondent cooperation over time and locating lost participants. A study's Web site may help to

report the findings to the public on a regular basis, help participants to update their personal information and researchers could maintain contact with the participants over time. The Web site helps to keep study participants engaged or interested in the study, which is evident from increases in response rates. For example, the NIOSH Survey response rates were 40% in 1995 and 30% in 1999. With the introduction of the Web site in 2001, response rates increased substantially to: Army (72%), Navy (74%), Air Force (74%) Marine Corps (58%) and Coast Guard (65%). These response rates are considerably higher compared to many military studies.

### 4. Recommendations

Many practical solutions for improving response rates for mail and internet surveys have been provided by Dillman (2000). He describes what is known as the Tailored Design Method (TDM). His survey methodology relies on the principles of social exchange theory and the development of survey procedures designed to foster an atmosphere of trust. These procedures increase perceptions of respondent rewards as they reduce perceptions of costs. The major goal of TDM is to reduce survey error by reducing non-response bias and minimizing measurement error by improving questionnaire development. For most sample surveys, researchers can easily adapt many TDM procedures to achieve higher response rates as it applies to their target population.

#### Respondent Friendly Questionnaires

The TDM emphasizes the development of questionnaires that are respondent friendly. Sample members will be discouraged from answering the questionnaire if the questions appear complicated or need research. Subjects will also be reluctant if it is not clear where answers should be written or how to proceed to the next question. Questionnaires must be designed with these factors in mind. Additionally, the initial question should be one that is relatively easy to answer and is interesting to the subject.

Fonts should be easy to read and large enough to be read by the sample members. Older populations would need larger font even if it increases the number of pages of the questionnaire. Color can be used to help guide sample members through the questionnaire and indicate where responses are required.

#### Multiple Contacts by First Class Mail with One by "Special" Contact

The most pivotal aspect of the Tailored Design Method is the use of multiple contacts, and especially one "special" contact. This method typically relies on five contacts throughout the survey period. They consist of 1) a pre-

notification letter, 2) the cover letter and questionnaire, 3) a reminder / thank you post card, 4) a second cover letter and replacement questionnaire, and 5) a final appeal, which is usually delivered or packaged in a special way.

A pre-notification letter can be used to introduce the sample member to the idea of the survey. It may explain the basic reason for gathering the information, endorse the survey and heighten the subject's curiosity for the questionnaire to arrive. It may also promise an incentive, which will increase the likelihood of the questionnaire envelope being opened. The use of a post-script can be very effective in the pre-notification letter. Sample members like knowing what to expect and it helps foster the sense of trust that is integral to this method.

The initial cover letter explains again what the survey is about and why it is important to answer the enclosed questionnaire. This envelope may also contain any financial or material incentive. This may make the envelope more bulky and more noticeable to the sample member.

A post card reminder or thank you will be printed at the same time as the initial batch of questionnaires and cover letters. All sample members will receive this mailing. Saying thank you to the respondents is important and is interpreted as a reward for doing what was asked of them. This post card also reminds other sample members to respond. This mailing is also unique because it is in a different form, post card rather than letter, from previous methods of contact. It does not have to be opened to be read. If this subject is unaware of the questionnaire they may look back through old stacks of mail to find the questionnaire mailing and respond.

Another cover letter and a duplicate copy of the questionnaire typically make up the fourth contact. This cover letter should not be a copy of the first letter. This letter should indicate that many people have responded, but that the specific sample member's response is still important and outstanding. The questionnaire should be included for those who have misplaced them.

The final notice should be sent in a way that identifies it as special and makes different appeals to the non-responder to complete and mail the survey. The previous appeals to complete the survey did not motivate the non-responders. Therefore sending repeats of what was sent before will not entice them to respond. A different approach to the non-responders must be found. A padded envelope or mail delivered through a special carrier, such as FedEx, may pique the interest of these non-responders, some who may have assumed the previous mailings where junk-mail.

The timing of the contacts is also important. The pre-notification letter can not be sent so early that the subject member forgets about the upcoming survey. The reminder postcard needs to be received within a week or ten days of receiving the initial questionnaire to encourage the potential respondents to find it lurking in their pile of unopened mail. The second letter and questionnaire should be sent a couple weeks after the post card so that those who responded can be removed from this additional mailing. The final notice may be more expensive due to its packaging or delivery method. It would be fiscally wise to wait for the replacement questionnaires to come back and remove any respondents from the list for the final mailing.

#### **Token Pre-Paid Financial Incentives**

Dillman shows that token incentives significantly increase response rates in mail surveys. A small pre-paid incentive has a larger impact on response than a much larger promised incentive (Dillman, 2000, p.167). Cash incentives may be problematic depending on the funding organization and administrative issues. A pre-paid incentive is indicative of trust between the researcher and the sample member. The sample member may feel socially obligated to complete the survey since they were already given the incentive.

#### **4.1 Tailored Design Method Applications in Many Military Studies and Other Major Studies**

Sponsored by the U.S. Department of Justice, the National Crime Victimization Survey (NCVS) uses several survey methodological features described by Dillman's TDM method. Probably of major importance is that the initial contact with sample households is face to face. It is at this time that the interviewer explains the importance of the survey and the importance of garnering the participation from each sample household. The first contact is an opportunity for the establishment of trust and provides a chance for participants to feel an investment in the study in the battle against victimizations. Although the study is not longitudinal, sample households are followed up to 3 years while being surveyed every 6 months. After the initial contact, subsequent interviews are conducted by telephone. For the 2005 NCVS, the eligible household response rate was 91% and the eligible individual participation rate was 84%.

The Frontline Treatment of Combat Stress Reaction study used several methods that resemble parts of the Tailored Design Method. Israeli military personnel involved in the 1982 Lebanon war were assessed in 1983 (Solomon, 2005) and assigned to treatment groups to determine if frontline treatment of post-traumatic stress disorder had a positive effect, compared to controls. Twenty years after the conflict, participants were contacted by telephone and

were asked to meet for a personal interview at their choice of location. The contact by telephone before acted as pre-notification for the actual questionnaire part. Since the respondent was allowed to select the place for questionnaire administration, the participant felt trusted with a decision and, in turn, could trust the confidentiality of their responses.

A survey of recently enlisted U.S. Navy women in 1996 and 1997 used multiple contacts, multiple methods of survey administration and incentives to improve response rates over typical rates for the Navy (Woodruff, et al., 2000). The initial mailed survey produced approximately 25% response. The response rate for the initial mailing was higher than the typical response rate (11% - 17%) for enlisted Navy personnel (Woodruff et al., 2000, Kantor et al., 1996, 1997). This increase over other surveys is most likely due to the use of incentives. The questionnaire was mailed with a phone card for 10 long distance minutes. Respondents were also entered into a lottery for \$100. Additionally, the subjects were able to respond by telephone, a second questionnaire, a brief postcard survey, and a final plea to call collect. These efforts, combined with continued incentives, more than doubled the response rate to 52% (Woodruff et al., 2000). This study is a good example of how the use of multiple contacts, multiple response methods and the inclusion of incentives can improve response rates in military studies. Similar to the Junior Military Personnel study, tobacco use was the subject of the study, and the response rate for Navy personnel at baseline averaged about 66%.

A study of smoking rates in a military field hospital achieved an 89% response rate. All personnel in 34 Field Hospitals during their sixth week of deployment to Iraq were eligible and 623 actually participated (Boos, 2004). This study achieved an 89% response rate of the 623 personnel. The high response rate is due in part to the very succinct questionnaire that contained only 12 items. Given the short questionnaire the study coordinators were able to gather the information that was relevant to their research questions and achieve acceptable participation.

The Department of Defense's Survey of Health-Related Behaviors achieved a response rate of 59% in 1998 (Lynch, 2004). This was a self-administered questionnaire that was completed by 17,264 members of the Army, Navy, Marines and Air Force. The authors indicate that special efforts were made to explain the responses would be anonymous. Establishing trust through ensuring confidentiality may have helped achieve this level of response.

An experiment regarding pre-paid incentives was carried out on a group of physicians in 1990 (Berk). Previous research by Barry & Kanouse (1987) and Armstrong

(1975) shows that pre-paid incentives work better than promised incentives. This study was designed to determine if providing a pre-paid incentive to non-responders was more effective than providing the incentive in the first mailing. One group of physicians received an upfront incentive of \$10. For the second group, only non-responders were given the \$10 incentive. The third group was the control, who did receive a \$10 token for their time without being informed. The pre-paid incentive group had an overall response rate of 63% compared to the second group with an overall response rate of 50%. The control group had only a 40% response rate. The evidence may indicate that incentives for mobile populations should be included in the first mailing rather than focusing on nonresponders.

Another reluctant population is elected political figures. Zeigler (2006) surveyed chief prosecutors in four states. He used the endorsement and multiple contact procedures from the Tailored Design Method to improve response rates. There was one state where endorsements could not be obtained. This showed the difference in response rates between multiple contacts and endorsements. Connecticut, where endorsements were unavailable, had a significantly lower response rate compared to the other states. It had a response rate of 61.54% where the next lowest response rate was in Oregon with 70.59%. Ziegler hypothesizes that there may be a synergistic relationship of multiple contacts and endorsements on response rates. This research indicates that substantial effort should be put into securing strong endorsements for military and mobile populations.

In addition to developing survey methodology that establishes an atmosphere of trust, two military studies by Schumm and others (2000) revealed how military personnel with a "greater investment" in society participated at higher rates. This work was an examination of mail survey response rates among male reservists. The study focused on male Reserve and National Guard members from the state of Ohio that participated in the Persian Gulf War. The sample of 3,582 reserve component personnel included 2,888 males with current Ohio addresses based on information from the DMDC. This study showed that veterans with a "greater investment" in society provided more valid addresses and participated at higher rates than those with less investment in society. A greater investment was defined by 11 demographic variables:

- higher military rank
- higher formal education
- greater residential stability in Ohio
- participated in the Persian Gulf War
- membership in the combined state/federal force (the National Guard) as opposed to the federal force (Reserves)

membership in the Air Force Reserve or the Air National Guard as opposed to land forces  
 having been married (currently married or separated) as opposed to being never married  
 greater number of years active military service  
 greater number of years of total (active and reserve) military service  
 greater age  
 majority ethnic background as opposed to a minority ethnic background.

For those with valid addresses, the response rate for majority veterans was 36.4% compared to 17.5% for minority veterans, and those with postgraduate study and college education were higher (38.2% and 41.3%) in comparison to those with just high school and less than high school (31.6% and 14.3%). Similar results were also found for female military veterans in a separate study conducted by Schumm, et al. (1999).

A longitudinal study on sexual harassment by Sims, et al. (2005) was conducted on a probability sample of 11,521 military servicewomen. The investigation was to determine the impact that sexual harassment had over approximately 4 years for actual personnel turnover for women. Turnover was defined as an individual leaving the military for reasons other than: retirement, death, transfer to an officer program, or conclusion of term of duty. Turnover was 13% overall women, higher among enlisted women (15%) in comparison to those among officers (8.5%). We can note that attrition due to turnover follows the same direction as that of survey response rates discussed by Schumm, et al. (1999, 2000), in that there is less attrition among the higher military ranks, which are considered to have a greater investment in society.

A common way of determining possible bias resulting from sample attrition is by comparing demographic variables in the initial sample at time-1 to those that exist at time-2. For example, this comparison method was used for a longitudinal study by Bolton, et al. (2005). This study was part of an investigation of a longitudinal examination of veterans of the Somalia peacekeeping mission. A total of 3,461 participants completed the initial questionnaire and 1,987 (57%) of these agreed to a subsequent follow-up for which 1,237 provided a phone number, and 522 of these agreed to an interview at time-2. It was determined that the demographic characteristics of the sample at time-2 were comparable and similar to those in the initial sample.

### 5. Summary of Results

Several survey methods presented in this literature review have shown that practical survey features described by Dillman (2000) can improve response rates. Securing as

much address information as possible at the baseline can reduce survey costs, while potentially improving survey response and reducing nonresponse bias. The researcher should also collect permanent address information at the baseline along with the current address of the sampling unit. If feasible, the researcher should collect at that time, the name and permanent address of a significant other. This person should be an individual who is likely to know the whereabouts of the sampling unit after the baseline.

Enthusiastic endorsements from military leaders are essential and should be included in the initial contacts. Tear-off postcards can be used to ensure anonymity of responses. Material incentives provided in the initial mailing helps in the establishment of trust and increases response rates. A second questionnaire should be mailed just in case sample personnel lost the original, and postal forwarded should always be implemented. The second postcard reminder should be different from the first postcard reminder. Both initial and follow-up communications should encourage personnel to respond as part of their duty.

An up-front material incentive, such as a ball-point pen, or an American flag button or phone card have shown to improve survey participation by establishing trust. Since financial incentives are generally prohibited by the military, the material incentive is a good alternative. A written pre-notification letter with endorsements can contain these incentives.

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