Coverage and Nonresponse Errors of Sampling Frames for Mail, Telephone, Face-to-Face, and Web Surveys

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INTRODUCTION

A general population survey is a survey of the general population of individuals who inhabit a specific area defined by geographic, political, or other boundaries (Johnston, 2000). Ideally, a general population survey samples from all individuals who meet the general criteria which defines the target population of interest; in practice, though, it is not uncommon for such a survey to exclude subgroups of the population (e.g., children under a certain age, homeless persons, individuals who do not speak the primary language of the geographic region, etc.) for feasibility of implementation (Johnston, 2000; Kish, 1965). Once inclusion/exclusion criteria have been identified, a sampling frame and sampling design are developed to guide the sampling process (Biemer & Lyberg, 2003).

A sampling frame is a list of members (or values/information that represent members) of a population (Dillman, Smyth, & Christian, 2009; Kish, 1965). Sampling frames are used in survey research as the pool of eligible participants from which the targeted sample is identified. Coverage – the degree to which all members of the population of interest are represented on a sampling frame for that population (Dillman et al., 2009; Groves, 1989; Lessler & Kalsbeek, 1992) – is a problem inherent to all frames available for the general population of the U.S. Coverage can be improved by combining two or more sampling frames into a single list (Lessler & Kalsbeek, 1992), but such practices have the potential to introduce additional challenges (e.g., overcoverage) without necessarily solving the limitations of a single frame (e.g., undercoverage, inclusion of ineligible elements). Coverage error, then, is the result of (1) a sample frame that does not include all members of the target population, or (2) the members of the target

population included in the frame being systematically different from those who are not included in the frame (e.g., de Leeuw, Hox, & Dillman, 2008; Dillman et al., 2009; Fricker, 2008).

Regardless of the quality of the sampling frame, all surveys are at risk for some level of nonresponse, which can introduce nonresponse error. Nonresponse occurs when members of the sample refuse to participate or cannot be contacted for recruitment purposes (Groves, 1989). Nonresponse error, then, occurs when members of the sample who refuse to participate in the survey are different from the members of the sample who participate in a systematic way on a variable of interest (de Leeuw et al., 2008). Nonresponse error can impact survey results at the unit or item level; only the impacts of nonresponse at the unit level are discussed herein.

When a research goal is to examine characteristics of both the general population and specific groups within the general population, oversampling may be employed. Oversampling is the process by which specific groups within the population are sampled at a higher rate than is consistent with their proportion within the general population (Biemer & Lyberg, 2003). Oversampling is conducted so that the specific sub-populations of interest are represented in the sample to the extent necessary to meet the goals of the research. It is common for survey researchers to specify groups for oversampling procedures based on demographic, social, or economic variables, or even by their geographic location. Area probability sampling is the process by which individuals on the sampling frame are divided into groups according to the geographic information that can be obtained about them, and the proportion of individuals in each geographic area impacts the portion of the overall sample that is drawn from each geographic area (de Leeuw et al., 2008). In the context provided for consideration here (general population survey with oversampling in New York, Chicago, Lincoln, and Los Angeles), the core sample would be sampled using area probability sampling at rates consistent with the

distribution of the general population. For example, if 25% of the nation's population resided in New York, then 25% of the sample would be selected from among available units in New York. The oversampling means that a second sample would be drawn from these locations above and beyond the core sample group. By increasing the number of units sampled from each location, the researcher increases those specific samples enough to enable himself to compare those locales or explore their characteristics.

The objective of this review is to describe the sample frames available for face-to-face, telephone, mail, and web surveys, and identify the strengths and weaknesses of each frame as they relate to coverage and nonresponse error. For the purposes of this review, it is assumed that the goal is to understand these issues within the context of a general population survey of adults (persons 18 years of age and older) living in the U.S., with an oversampling of individuals living in New York, Chicago, Lincoln, and Los Angeles.

MAIL SURVEYS

A general population survey of the U.S. conducted by mail requires redefinition of the target population to individuals who live in a permanent dwelling or maintain a post office box (e.g., Lessler & Kalsbeek, 1992). Despite the longevity of mail surveys, there are serious disadvantages associated with their use. Though not a complete list, some such limitations include the absence of an interviewer to help encourage participation and complete responses, the language in which the survey is written is not a language spoken or understood by the recipient, exclusion of individuals who do not live in a permanent dwelling, obtaining a complete sampling frame can be difficult, and the researcher is unable to enforce any within-household selection methods. Only difficulties surrounding the development of a sampling frame and unit-level nonresponse will be addressed here.

Sampling Frame

Sampling frames for mail surveys can be developed in many ways, including from listings of addresses such as phone books and direct enumeration. Enumeration is the process by which geographic areas are visited and the addresses of all dwelling units are recorded or verified (Iannacchione, Staab, & Redden, 2003). Due to advances in technology and computerized databases, researchers are no longer forced to rely on sources such as phone books or enumeration of addresses for the development of sampling frames (Battaglia, Link, Frankel, Osborn, & Mokdad, 2008). Instead, researchers can purchase portions of the United States Postal Service (USPS) Delivery Sequence File (DSF) from licensed vendors to use as the basis for their sampling frame. The DSF is a computerized database that contains all delivery point addresses that receive service from the USPS with the exception of general delivery addresses (Battaglia et al., 2008; Iannacchione et al., 2003; USPS, 2005). Although the DSF contains only addresses and not residents' names, it does distinguish between residential and business addresses (Iannacchione et al., 2003). The USPS maintains – and continues to improve and develop – the DSF, but they do not provide the list directly to researchers; third-party vendors purchase the DSF directly from the USPS and make it available for purchase to researchers, marketing firms, etc. in whole or in part (Dohrmann, Han, & Mohadjer, 2006; Iannacchione et al., 2003).

Coverage. Regardless of how a sampling frame is developed for a mail survey, it is not likely that complete coverage will be obtained. Dillman et al. (2009) point out that, despite its limitations, the DSF has been found to be an effective tool for increasing the coverage obtained in the development of sample frames. However, even though the DSF has provided a breakthrough with regard to the development of a sampling frame and it is maintained by the USPS, it is known to not provide complete coverage. For example, the DSF fails to provide good coverage of rural (Dohrmann et al., 2006; Link, Battaglia, Frankel, Osborn, & Mokdad, 2005;

Staab & Iannacchione, 2003) and lower income areas (Link et al., 2005), and fails to provide any coverage for residential addresses that do not fall along a delivery route (Dohrmann et al., 2006). The fact that the DSF includes addresses only for delivery points is important because many people throughout the country do not live on a USPS delivery route and receive mail from a general delivery facility or a post office box. Individual residence/business addresses that exist as part of some apartment complexes, assisted living facilities, college dorms, shelters, etc. are frequently excluded from the DSF, as such facilities typically utilize a general delivery facility (Dohrmann et al., 2006; Johnston, 2000). Such omissions can be the source of undercoverage within a sampling frame.

In addition to the coverage errors introduced by the structure and maintenance of the DSF by the USPS, additional sources of non-coverage are introduced by the process of brokering the list or pieces of the list through third-party vendors. Such additional sources of coverage error include: (1) the version of the DSF to which the vendor has access may not contain the most current information, and (2) vendors are required to remove addresses from their lists upon resident request (Iannachione et al., 2003). This latter issue is problematic because a DSF list obtained from two different vendors at any given point in time may be different even if the vendors obtained their lists at the same time. On the other hand, it would be possible for a survey team with adequate resources to obtain DSF lists from multiple vendors and combine them to create a more complete frame.

Nonresponse error. At the survey level, mail surveys are prone to nonresponse. With the growing reliance on the DSF as a sampling frame and the challenges inherent to mail surveys, there is a limit to what a researcher can do to minimize survey nonresponse. Regardless of the considerations taken during survey design and recruitment, a mail survey means that the

researcher has no way to know whether lack of participation indicates the address was bad, no one lives in the home, the language of the survey did not match that of the resident, the within-household selection method was confusing/invasive, or the occupant(s) decided not to participate. Such problems often lead to nonresponse errors but because the survey is conducted via mail, it is often impossible for the researcher to find out why nonresponse occurs and adjust estimates accordingly.

TELEPHONE SURVEYS

The growth of cellular phones and the changing attitudes toward landlines has added several layers of complexity to the process of developing a sampling frame for telephone surveys – particularly one with perfect coverage (de Leeuw et al., 2008; Dillman et al., 2009). Especially problematic for survey researchers are households that do not have a landline and rely on cellular phones because they increase the degree of undercoverage, and households that have both landlines and cellular phones because they increase the level of overcoverage (Kennedy, 2007). Due to the evolving relationship between people and telephones, researchers have developed more creative methods for developing a sampling frame. For example, Shuttles, Link, and Smarr (2008; as cited by Dillman et al., 2009) outlined a process by which addresses are obtained using the DSF, and those addresses are matched to other lists that contain phone numbers. Because such a list includes delivery addresses, it is possible for researchers to estimate the level of coverage available with phone numbers. An additional advantage is that if the DSF is supplemented with other lists which include cellular phone numbers, the researcher gains access to persons who cannot be contacted via RDD.

A common method for phone surveys is random digit dialing (RDD; de Leeuw et al., 2008), in which an algorithm is used to generate phone numbers. Though once considered a standard within the field of survey methodology (CITATION), RDD is not able to change to

meet the developing landscape of cellular phones. In fact, a recent study demonstrated higher response rates with a mail survey based on a DSF sampling frame than with RDD (Link, Battaglia, Frankel, Osborn, & Mokdad, 2008), though RDD had a lower rate of nonresponse from lower socioeconomic groups.

RDD is not free of limitations with regard to coverage, however, as RDD cannot be used with cellular phone numbers, and there is never a guarantee that the number generated is a residential number that is in service, or that each number corresponds to a unique residence (de Leeuw et al., 2008). A weakness of sample frames for telephone surveys of the general population is that all households/persons without a landline or cellular telephone are excluded from the sample (Groves, 1989). In practice, this means that important parts of the population – whole groups of people with unique characteristics such as homeless and transient persons (Iachan & Dennis, 1993; Martin, 2007; Martin, Laska, Hopper, Meisner, & Wanderlings, 1997) – are excluded from the sample. Even in the presence of a perfect sampling frame, the use of technology with telephone surveys can introduce coverage errors (i.e., someone who does not own a touch-tone phone cannot complete a survey administered by an automated computer system; de Leeuw et al., 2008). With regard to within-household selection (which will not be addressed here), the interviewer can help reduce coverage by leading the respondent through the within-household selection procedures correctly and fully (Martin, 1999

With reference to response error and, more generally, response rates, telephone surveys are somewhat a double-edged sword. On the one hand, they offer respondents a human (or computer; Dillman, 2008) with whom to interact, the interviewer takes on the role of within-unit selection and leading the respondent through the survey process, etc. (Loosveldt, 2008; Oldendick, Bishop, Sorenson, & Tuchfarber, 1988). On the other hand, some respondents may

be less inclined to phone surveys due to privacy reasons (e.g., they are not in a position to speak about private matters without being overheard, they do not want to provide information for interviewer to enumerate the members of the household, etc.. An advantage of phone surveys conducted with human interviewers over survey modes that do not utilize a human interviewer or any interviewer at all is that the social interaction encourages respondents to complete the survey once they have begun, and the interviewer can clarify questions for the respondent (as appropriate within the context of the survey) and record reasons for unit or item nonresponse (Loosveldt, 2008).

FACE-TO-FACE SURVEYS

Face-to-face surveys generally employ the same sampling frames as mail surveys, and so the reader is referred to the Mail Survey section (above) for a review of such methods.

Coverage. Generally speaking, the sampling frames available for face-to-face surveys face the same limitations described for mail surveys. However, because face-to-face interviews require the physical presence of an interviewer, they have the potential to overcome some of the challenges related to coverage. For example, an interviewer in the field has the potential to overcome the challenges associated with mail or telephone contact between researchers and hard-to-reach populations (Biemer & Lyberg, 2003). An interviewer visiting the physical neighborhoods also has the opportunity to verify the addresses that exist on the sampling frame and identify units that were not included (CITATION). Though this would happen after the sample has been drawn, it would allow researchers the opportunity to make statistical adjustments as appropriate.

Nonresponse error. The presence of an interviewer also has strengths and weaknesses with regard to nonresponse error. On the one hand, the presence of the interviewer helps encourage complete responses and the interviewer is able to provide information regarding why

a targeted sample member did not participate (e.g., could not be contacted, opted to not complete the survey; Biemer & Lyberg, 2003; Loosveldt, 2008). On the other hand, characteristics of the interviewer could influence whether someone agrees to participate (Loosveldt, 2008).

WEB SURVEYS

A web survey is one that relies on the Internet for participant recruitment and survey completion (Dillman et al., 2009). Such a survey may use e-mail recruitment and survey administration, e-mail recruitment with non-email survey administration, non-e-email recruitment and e-mail administration, or non-e-mail recruitment and non-e-mail administration. Regardless of which of these approaches is implemented, the target population must be re-defined (Lessler & Kalsbeek, 1992) from all adults living in the U.S. (as stated in the introduction section of this paper) to all adults living in the U.S. who have access to and use the Internet. If the goal is a general population survey of U.S. adults, the re-defining of the target population in this way has obvious implications, including a lack of generalizability due to Internet user characteristics (Dillman et al., 2009; Fricker, 2008) and the fact that Internet usage is not common to all U.S. adults, with approximately 22% of adults who use live in the U.S. choosing to not use Internet as recently as August, 2011 (Zickuhr & Smith, 2012).

Sampling Frame

There is no national database or directory of email addresses. This is due in part to the fact that e-mail addresses are not constructed in a systematic way, which makes the development of methods to randomly generate e-mail similar to RDD largely ineffectual (de Leeuw et al., 2008; Dillman et al., 2009). Further, Internet access is not a feature of all households or even a tool used by all residents in homes that do have online access (Fricker, 2008). By their very nature, web surveys exclude homeless and transient populations in the same ways as mail and phone surveys. Thus, there is no good source of information from which to develop a sampling

frame for a web survey of the general population, nor is such a survey feasible in today's world. It is important to note that it is feasible to obtain/construct a sampling frame for specific sub-groups of the population (e.g., individuals employed at specific companies, university students, parents of public school students, etc.; de Leeuw et al., 2008; Fricker, 2008), assuming the researcher has permission to use such lists.

With no known way to effectively overcome the challenges of sampling frame development inherent to web-based research, some researchers have come to rely on convenience samples in which participants click on a link from a web site to visit and complete the survey (de Leeuw et al., 2008). Unfortunately, this approach does not solve any of sampling frame problems (Manfreda, & Vehovar, 2008), as it is impossible to determine coverage in such situations where the target population is no more clearly defined than individuals who visit a specific site or set of sites.

Coverage. Internet surveys are extremely susceptible to coverage error (de Leeuw et al., 2008; Dillman et al., 2009), particularly in comparison with face-to-face, telephone, and web modes. The explanation for this difficulty is multifaceted and relates to the relative newness of the Internet, the expenses associated with technologies and services necessary to access and effectively navigate the Internet, and the extent to which the proportion of the population who uses the Internet varies on other important demographic variables (Zickuhr & Smith, 2012). In the context of a research study intended to target specific subpopulations of the population (e.g., students), the coverage provided by the frame may be quite high or even one-to-one for the target population. In the context of a general population survey, however, the coverage provided by specific sup-group frames list these would be extremely low and, arguably, unusable because sending an e-mail to someone requires a prior relationship with them (Dillman et al., 2009). Just

as a side note, some limitations of coverage may be overcome using a mixed-mode approach to the web survey in which a non-web format is used during the initial contact and participant recruitment phase of the study (Dillman et al., 2009). The implications of such mixed-mode methods are beyond the scope of this paper.

Nonresponse error. For the sake of argument, imagine the government issues e-mail addresses to U.S. residents above the age of twelve, the practice is implemented perfectly, and the federal government maintains a list of those e-mail addresses for the sole purpose of enabling researchers to obtain more representative samples. Even with such a perfect frame for a target population of all adults in the U.S., the nonresponse error associated with Web surveys is rampant due to individual characteristics of people (e.g., age, household income, education; Zickuhr & Smith, 2012). For example, the Pew Research Center (Zickuhr & Smith, 2012) reported in April that 20% of adults in the U.S. do not use the Internet and 50% of those adults do not share a household with an Internet user. It was also found that 2% of adults in the U.S. have a disability that prevents them from using the Internet. Because not all adults in the U.S. are Internet users, the development of a good sampling frame for a general population survey of U.S. adults is not enough to fix this particular problem.

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