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Dual Frame Web–Telephone Sampling for Rare Groups

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This article considers the conditions under which dual frame web–phone designs may be cost-effective for sampling rare groups within the general population. We show that savings may be available from combining web and telephone to take advantage of the low cost of the former and the high coverage of the latter, but the situation is more complex than one might have expected. We suggest guidelines for implementing such studies, and discuss the implications of changes in our design assumptions.

Key words: Sampling; rare groups; web surveys; online surveys.

1. Introduction

Survey researchers have long been interested in cost-effective methods for sampling rare groups within the general population. The goal is to reduce screening costs, which dominate the total costs of studying such groups. For example, if the target group comprises 2% of the general population, 50 screeners are needed to locate each group member unless sampling efficiency is improved in some way. The resulting costs can strain any research budget.

Sampling methods that have been used to improve the efficiency of reaching rare groups include cluster sampling, disproportionate stratified sampling, network sampling, and dual frame sampling (Kalton 2001). These sampling methods have frequently been used in the context of telephone data collection because of its combination of moderate cost, excellent population coverage and reasonable response rates. In particular, Blair and Blair (2004) have recently argued that telephone cluster sampling is more useful than has previously been recognized. They show that the relative effectiveness of this procedure rises as the target group becomes more rare, so that meaningful gains in efficiency are possible for very rare groups even if they are only mildly clustered within telephone banks.

In the present article, we consider whether web-based data collection also may be useful in reducing the costs of studying rare groups. The sampling deficiencies of online surveys

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are well-known (e.g., Couper 2000): response rates are low, and there is substantial exposure to coverage bias because online access varies widely across income and ethnic groups. However, given the cost challenges of studying rare groups, if data can be gathered at lower cost on the web, then one might consider dual frame designs in which the web is used for target group members who are accessible online and telephone (or some other method with broad coverage) is used for those who are not online. Such designs may provide a desirable blend of cost and coverage. Also, if online questionnaires are found to perform like other self-administered forms of data collection, then having an online component in the data collection may provide useful information about potential biases in sensitive items. This is not our main motivation for considering web-based data collection, but it is worth noting that rare population screening studies often include sensitive questions.

The logic of using web-based data collection for rare groups is that the web should have lower screening costs than other methods because no incremental labor or postage is needed to contact potential respondents. This reduction in costs is not dependent on geographic clustering in the target group, so web-based data collection may offer savings where telephone cluster sampling cannot. More broadly, the question is whether the web may offer advantages even after accounting for the benefits of telephone clustering as described by Blair and Blair (2004).

To address this question, we compare the costs of telephone interviewing using cluster sampling (under various levels of target group prevalence and clustering) with analogous costs of web-based data collection. We consider two scenarios for web-based data collection, in which participation is solicited from (a) members of opt-in lists and (b) members of online panels. Our results show that web–phone designs for sampling rare groups will offer cost savings (vs telephone-only) under certain circumstances, but the situation is more complex than one might have expected.

Throughout our discussion, the presumed context is that (a) a rare group is of interest, which usually implies that the group comprises no more than 20% of the general population and often far less, (b) there is no special list that, in itself, provides adequate coverage of this group, so the group must be found by screening the general population, and (c) the data in question can be gathered effectively by web or by phone.

2. Background: Telephone Cluster Sampling

In comparing the costs of telephone and web-based data collection, we presume a preference for telephone-only designs unless the web has a clear cost advantage, because of the better population coverage and response rates available via telephone. Therefore, the question is not simply whether web-based data collection can be cheaper than simple telephone procedures, but whether it is cheaper than *efficient* phone procedures. In this regard, we follow Blair and Blair (2004) and presume the use of telephone cluster sampling where it is justified.

Telephone cluster sampling (TCS) for rare groups is a variation of Mitofsky-Waksberg sampling (Waksberg 1978; 1983). It was described by Blair and Czaja (1982), based on a suggestion from Seymour Sudman, and further described in Sudman (1985). The procedure works as follows. A random number is dialed within a bank of telephone numbers: this number can be selected via list-assisted random digit dialing (RDD) or any other procedure. If the number does not produce a member of the target group, then no further sampling is done within the bank. However, if a group member is found, further sampling is done in the bank until a prespecified number of group members are identified (according to Blair and Blair 2004, three is typically a good number). This procedure has the effect of rapidly dropping telephone banks with no target group members and "fishing where the fish are" for additional members of each cluster.

The usefulness of TCS for sampling a rare group depends on the extent to which the group is geographically clustered. If the group is spread evenly across telephone exchanges and there are few phone banks in which it does not occur, then TCS will increase the operational and administrative difficulty of the research without improving its efficiency.

According to Blair and Blair (2004), the usefulness of TCS also depends on the extent to which the target group is rare. The intuition is that as first-stage respondents become harder and harder to find, it becomes increasingly beneficial to look near those respondents for others like them if there is even a mild tendency for respondents to cluster within phone banks, while if first-stage respondents are easy to find, then there is little to gain from clustered sampling, even given a strong tendency to cluster.

Blair and Blair (2004) show that the efficiency of TCS can be expressed through the relationship $\boldsymbol{\pi}' = [\boldsymbol{\pi} + \boldsymbol{\rho}(1 - \boldsymbol{\pi})]$, where $\boldsymbol{\pi}$ is the screening rate for "first calls" into random telephone banks, $\boldsymbol{\pi}'$ is the screening rate for subsequent calls into telephone banks where the first call has produced a member of the rare group, and $\boldsymbol{\rho}$ (rho) is the coefficient of homogeneity within telephone banks for the defining characteristic(s) of the target group. So, for example, if the first-stage screening rate $\boldsymbol{\pi} = .10$, or 10%, and $\boldsymbol{\rho} = .05$ (which, in Sudman 1985, is a "realistic value for a broad range of consumer and household variables"), then the subsequent screening rate $\boldsymbol{\pi}' = .10 + .05(.90) = .145$, or 14.5%, which is a 45% improvement over the first stage. If the first-stage screening rate $\boldsymbol{\pi} = .01$, or 1%, a $\boldsymbol{\rho}$ of .05 will produce an almost six-fold gain in screening efficiency from first to second stage (from 1% to 5.95%), and even a $\boldsymbol{\rho}$ of .02 will produce a near trebling in efficiency (from 1% to 2.98%). Results such as these lead Blair and Blair (2004) to argue that TCS should be a routine procedure for sampling very rare groups even if those groups are not noticeably clustered in the general population.

Here, we will presume the use of TCS with a cluster size of three if there is any nonzero clustering in the target group (as suggested by Blair and Blair 2004), and we will presume simple list-assisted RDD if there is not. Although a specific value of rho may not be known before the research unless information is available from previous studies, as shown above, the TCS method is robust enough that for very rare populations, even fairly small values of rho would support its use. In instances where it is important to know rho more precisely, an estimate may be obtained from a pilot survey: a procedure we recommend generally since design assumptions for rare population screening are often sufficiently inaccurate as to have important effects on costs. Another approach is to use an adaptive sampling design in which the design parameters are estimated in the initial phase of the study (Blair 1999).

3. Costs of Telephone vs Opt-In Web Lists

Having set the context for our use of telephone cluster sampling, we will proceed to compare the costs of telephone interviewing using TCS (under various levels of target group prevalence and clustering) with analogous costs of web-based data collection using (a) members of opt-in lists and (b) members of online panels. We will not consider a third possibility for web-based data collection in which the questionnaire is posted on an open web site for anyone who wishes to participate. Obviously, this third method generates a pure sample of volunteers.

Our first comparison involves opt-in lists. Opt-in lists consist of people who have agreed to receive e-mail communications on some topic; for example, they may have indicated that they are willing to receive communications from an online travel agency that subsequently sells their e-mail addresses to a list vendor. Since these people have opted into receiving communications, it is considered acceptable to solicit their participation in a survey (though a survey solicitation may be classified as "spam" by the respondent's spam filter). However, in agreeing to receive email, these people typically did not mean to encourage survey requests, and their response rate is correspondingly low. In half-a-dozen surveys with opt-in frames, we have mostly observed response rates in the range of 4% to 8%, and the vendor Survey Sampling, which sells such lists, suggests that response rates of 3% to 5% should be expected. The good news about these lists, from a sampling point of view, is that they contain more people than online panels (for example, Survey Sampling has at least seven million e-mail addresses on its collective opt-in lists), and these people are not on the lists because they are research volunteers. On the negative side, low response rates raise concerns about nonresponse bias. We will address these points in our conclusions.

The results of our comparison between telephone and opt-in web are shown in Table 1. The numbers in Table 1 represent ratios of web costs to phone costs, so a number below 1.00 indicates that web costs less than phone and a number above 1.00 indicates that web costs more.

Specific cost assumptions underlying Table 1 are as follows. For opt-in web, we assume that each e-mail address costs 25¢, which is consistent with Survey Sampling's pricing (opt-in addresses are available from other list brokers for lower prices). We assume a 5% response rate, which is consistent with our prior experience and on the high side of Survey Sampling's guidelines. We assume no other costs of data collection apart from the fixed costs of programming and hosting the questionnaire. Therefore, we assume that the cost per complete is (25¢)/(.05), or \$5.00, further divided by the screening rate for the target group. We take the screening rate to be the prevalence of the target group within the general population, and we will discuss the implications if these figures differ. Finally, for simplicity, we assume that the cost per complete is unaffected by whether or not follow-up "mailings" are sent (Survey Sampling charges half of the initial cost per name to send

Table 1. Relative cost per complete for web-based data collection with opt-in samples vs TCS telephone interviewing given π (the screening rate for the target group) and ρ (the target group's tendency to cluster)

	$\rho = 0$	$\rho = .02$	$\rho = .05$	$\rho = .10$	$\rho = .20$
$\pi = 1\%$	0.88	1.56	1.92	2.15	2.31
$\pi = 2\%$	0.86	1.26	1.57	1.82	2.02
$\pi = 5\%$	0.80	0.95	1.12	1.29	1.48
$\pi = 10\%$	0.72	0.79	0.85	0.95	1.10
$\pi = 20\%$	0.59	0.61	0.65	0.68	0.74

a follow-up solicitation). For telephone interviewing, if the target group has zero tendency to cluster geographically, we assume a simple list-assisted RDD design, and if the target group has a nonzero tendency to cluster, we assume the use of telephone cluster sampling with list-assisted RDD at the first stage and a cluster size of three, following Blair and Blair (2004). We do not consider further gains that might be available from disproportionate stratified sampling (cf. Blair and Blair 2004). We consider only the costs of sampling, data collection, field supervision, and validation, not including project set-up, data analysis, and general overhead. We assume a 10-minute interview with fully allocated costs of $15 per main interview and $5.50 per completed screener (the cost per screener includes allocated costs of nonworking numbers, noncontacts and refusals to participate, and presumes the use of unlimited callbacks until all numbers reach final disposition). These are representative of costs recently experienced by the Survey Research Center at the University of Maryland. Commercial market research costs are likely to be lower, largely because of fewer callbacks. We do not incorporate design effects arising from the weighting of unfilled clusters and/or intra-cluster homogeneity for the variables to be measured. One might argue that these factors should be considered, to compare the costs of "information equivalents," but since we are unable to make any comparable adjustment for the possible non-srs (simple random sample) character of web samples, we simply compare the two methods on cost per complete. If one wishes to incorporate assumptions about design effects into the comparison, or to change any of our other assumptions, it is a simple matter to rescale the numbers accordingly.

Table 1 shows that if the target group has no tendency to cluster geographically (i.e., $\boldsymbol{\rho} = 0$), web-based data collection with opt-in samples consistently costs less than telephone. This might be viewed as a baseline scenario for opt-in web vs phone, because it presumes a simple RDD design without clustering. Under this scenario, at a screening rate of 1%, web-based data collection costs 12% less than telephone. The savings rises to 20% at a screening rate of 5%, and to 40% at a screening rate of 20%.

If the target group has any tendency to cluster geographically, then opt-in web may or may not cost less than telephone interviewing with TCS, depending on the prevalence of the target group. In Table 1, if $\boldsymbol{\rho}$ is at least .02, opt-in web generally costs more than telephone if the screening rate ($\boldsymbol{\pi}$) is 5% or less. The specific dividing point will depend on one's cost assumptions, but as a general rule there will be a level of rareness beyond which TCS dominates opt-in web unless the opt-in list has a superior screening rate.

More broadly, Table 1 shows that web-based data collection with opt-in samples becomes relatively *less* cost effective as the target group becomes more rare. This finding, which may contradict many people's intuition, is robust and will hold even if our specific cost assumptions are changed. To some extent, it occurs because opt-in web costs are more linear than telephone costs with respect to screening rates for the target group (the screening portion of telephone costs is linear with respect to screening rates, but the main interviewing portion is not, while web costs are completely linear). To a larger extent, given any geographic clustering in the target group, this finding occurs because the relative effectiveness of TCS increases as the target becomes more rare, as mentioned earlier.

Note that even when web costs are higher than telephone costs in Table 1, the ratio generally does not exceed two. This implies that if one can find an opt-in list in which the prevalence rate of the target group is at least twice as high as the prevalence rate in the general population, then cost savings should almost always be available by using the web in a dual frame design (given our assumptions, and assuming that the cost of the list does not absorb the benefit). Likewise, cost savings should be available from the web if one can achieve online response rates at least twice as high as the 5% assumed here.

Since the relative cost-effectiveness of opt-in web vs telephone depends on the target group's prevalence in the general population (or in a specific opt-in list), a potential issue in using opt-in web is estimating the prevalence rate. Unlike web panels, the nature of opt-in frame construction does not produce much information about the characteristics of list members, so in many instances it may be necessary to conduct a pilot study to estimate prevalence. Fortunately, since Table 1 suggests that opt-in web is likely to be cost effective only when the target group is not too rare (or when a relatively rich list is available), a pilot study sample need not be very large to determine the prevalence rate with acceptable accuracy.

To summarize: given our cost assumptions, dual frame web–phone designs with opt-in web lists will consistently allow one to study rare groups at a lower cost than simple RDD telephone designs. If the target group has some nonzero level of geographic clustering, and TCS is used, web–phone designs will still typically allow cost savings if one has access to an opt-in list in which the prevalence rate for the target population is at least double the prevalence rate in the general population. In the absence of such a list, and given nonzero clustering, the benefits of web decline as the target group becomes more rare, and telephone interviewing has a general cost advantage for groups with prevalence rates of 5% or less, thanks to the benefits of TCS.

Changes in our assumptions will affect the results as follows:

- Telephone costs: Commercial market research costs for telephone interviewing will tend to be lower than the numbers used here, which are drawn from an academic, social research facility that uses unlimited callbacks (as well as heavier supervision and training than is the norm for commercial vendors, at least for smaller field houses). Any such reduction in telephone costs will reduce the relative attractiveness of web-based data collection and narrow the circumstances in which use of the web is justified by its benefits.
- Design effects: Table 1 is based on the raw cost per case, not "information equivalents," and does not incorporate telephone design effects resulting from cluster sampling or weighting of unfilled clusters. Incorporating those factors along with cluster administration costs will increase the effective cost of telephone interviewing, most likely by 20%–30% at a cluster size of 3. This will enhance the relative attractiveness of web.
- Web response rates: Table 1 presumes a 5% response rate in web-based data collection. This is in line with our own experience, but at the high end of the 3%–5% advised by Survey Sampling. Lower response rates will reduce the relative attractiveness of web-based data collection and narrow the circumstances in which use of the web is justified by its benefits.
- Web prevalence: Table 1 assumes that the target group's prevalence rate in the online population matches its prevalence in the general population. If this is not true, and the target group is overrepresented in the online population, the screening rate will benefit accordingly, and web-based data collection will be proportionately cheaper.

A simple example is if the target group is Internet users. On the other hand, if the target group is underrepresented in the online population, as is true for lower income and lower education groups, the screening rate will suffer accordingly, making web-based data collection less attractive.

- Web screening efficiency: Table 1 assumes no efficiencies in the screening rate for web-based data collection; in other words, it assumes that the screening rate will match the target group's prevalence rate in the online population. If the web frame contains information that allows users to be screened for the defining characteristic of the target group, or if it contains related information that allows stratification to build efficiency, then web-based data collection will gain substantial cost advantages. Also, if the defining characteristic of the target group is socially sensitive, such as males who have sex with males, the self-administered web mode may benefit from increased willingness to admit group membership, but this is speculative: at this time, it is unknown whether the tendency for better reporting of sensitive characteristics found in other self-administered modes will carry over to the web.

All of these changes will affect the specific ratios shown in Table 1, but none of them will affect the general pattern that web-based data collection with opt-in samples becomes relatively *less* cost effective as the target group becomes more rare.

4. Costs of Telephone vs Online Panels

We now consider the costs of using online panels for rare groups. Online panels consist of people who have agreed to participate in research projects: examples include the panels maintained by Harris Interactive, Ipsos-NPD, Decision Analyst, and Survey Sampling. These panels typically contain at least 200,000 members. Since the members have explicitly agreed to participate in research, usually with some system of incentives, panel vendors often will guarantee some level of response, and in our experience a 50% response rate is common. A positive sampling feature of web panels is that demographic characteristics (and other information) are known for individual panel members, which allows sorting or stratification that may improve screening efficiency. However, on the negative side, a web panel can be viewed as a collection of volunteers. Also, a large sample of a rare group may strain the capacities of the panel; for example, if the target group represents 1% of the general population, and one posits a 50% response rate, then 200,000 panel members are needed to generate 1,000 completes.

From a cost perspective, a key point with regard to web panels is that vendors tend to view themselves as selling studies, not samples, and they may offer relatively fixed prices that are economical for studying rare groups, especially if a large sample is used. In this regard, we obtained cost estimates from Ipsos-NPD for using their web panel at various sample sizes and prevalence rates. At the time of our inquiry, Ipsos-NPD maintained a panel with more than 300,000 members. Their estimates were expressed as total costs for data collection, and we have converted these estimates to an implied cost per case relative to telephone data collection (assuming the use of TCS and $\boldsymbol{\rho} = .05$). Results are shown in Table 2, along with comparative costs for opt-in samples.

These results show that substantial savings may be available from using web panels to study rare groups if (a) the target group is very rare and/or (b) the sample will be large.

Table 2. *Relative cost per complete for web-based data collection with web panels (and opt-in samples) vs TCS telephone interviewing*

	Cost of TCS telephone with $\boldsymbol{\rho} = .05$ (clusters of 3)	Cost of web with an opt-in sample	Cost of web panel at $n_{\text{panel}} = 250$	Cost of web panel at $n_{\text{panel}} = 500$	Cost of web panel at $n_{\text{panel}} = 1,000$
$\boldsymbol{\pi} = 1\%$	1.00	1.92	0.63	0.50	0.43
$\boldsymbol{\pi} = 2\%$	1.00	1.57	0.72	0.51	0.41
$\boldsymbol{\pi} = 5\%$	1.00	1.12	1.02	0.64	0.46
$\boldsymbol{\pi} = 10\%$	1.00	0.85	1.29	0.73	0.44
$\boldsymbol{\pi} = 20\%$	1.00	0.65	1.79	0.95	0.51

The relationship of costs to prevalence is particularly interesting. In Table 1, we saw that web-based data collection with opt-in samples becomes relatively *less* cost-effective as the target group becomes more rare. In Table 2, we see the opposite. Web panels become *more* cost-effective as the target becomes more rare. It should be emphasized that these results occur if the panel vendor prices on a relatively fixed cost basis. If a vendor charges a cost per name for access to its web panel – as does Survey Sampling – the costs of using the panel will perform in a manner similar to opt-in lists.

Of course, the specific results shown in Table 2 will vary with changes in the underlying cost assumptions. For example, another online panel vendor, Decision Analyst, has costs for web data that are somewhat lower than those used in Table 2, and using these costs would enhance the relative advantage of web data. Likewise, using the lower telephone costs that one might expect for commercial vs academic work would reduce the advantage of web data. However, the general finding that web panels become *more* cost-effective as the target becomes more rare should endure as long as a web panel vendor prices on a relatively fixed cost basis.

5. Conclusions

Overall, the results shown in Tables 1 and 2 should be viewed as suggestive, not conclusive, because they rely on specific cost assumptions and will change over time. What is most important is the pattern of results. Cost savings clearly may be available from dual frame web–phone designs (vs telephone-only), but the situation is more complex than one might have expected. Web-based data collection with opt-in samples becomes financially *less* attractive vs telephone-only as the target group becomes more rare, while web-based data collection with panel samples may become financially *more* attractive if the panel vendor prices on a relatively fixed cost basis.

Either way, dual frame web-phone designs will typically offer savings over telephone-only designs if one has access to an online list in which the target group's prevalence rate is at least twice as high as in the general population. This is very much in the broader tradition of using dual frame designs where one has access to a special list. There are two general situations in which this will occur. First, if the target group is defined by the purchase or usage of Internet or computer-related items, any online sample may yield a higher prevalence than the general population. For example, we recently needed a sample of people who had purchased a computer within the past twelve months and were regular readers of a national publication in which certain advertising had appeared. It was natural to look for these people online. Second, even if the defining characteristics of the target group are not related to computers, they may be identifiable in web frames, or may have demographic correlates that enable the efficient selection of an opt-in list or the efficient sorting of a panel.

Given the cost benefits that might be available from web-based data collection for rare groups, should this method be used? The answer depends on one's willingness to treat a web sample as representative of the larger online population.

There are three major sampling issues currently associated with web-based research. One of these issues is the potential for coverage bias stemming from the fact that many members of the general population are not online. A second issue is the potential for coverage bias – or volunteerism bias – stemming from the fact that available sampling frames cover only a fraction of the online population (for example, in the U.S., a panel of 200,000 members represents well under 1% of the more than 100 million Americans who are currently online). A third issue is potential nonresponse bias stemming from low response rates, at least for opt-in samples.

The first issue, coverage bias based on web access, is addressed by the use of a dual frame web–phone design, because the online portion of the research need only represent the online population. The second issue, coverage bias in the online frame, is more difficult to address. A theoretically clean approach to this issue is to stratify the population on the basis of "in frame vs not in frame" rather than "online vs not online." However, this approach is of little practical use, because if the "in frame" stratum contains only a small percentage of the total population, as is typical with online frames, then the optimal allocation to this stratum will be too small to justify the incremental costs of web-based data collection. There also is the practical difficulty of getting telephone respondents to give an accurate indication of whether they appear in any given online frame, so they can be sorted out. Overall, the only practical response to possible coverage bias in the online frame is to manage it through sample balancing, as would be done with a panel sample, or through poststratification. Likewise, regarding the issue of nonresponse bias, one must do one's best to maximize the response rate, and consider the possible usefulness of poststratification.

In these regards, an important feature of dual frame web–phone designs is that they will allow a comparison of web and phone results. If results from web and phone do not differ, one generally might assume that the effects of coverage bias and nonresponse bias in the web data are negligible. If the results do differ substantially by mode, that difference might be caused by coverage or nonresponse bias, or might reflect legitimate differences between the two strata (for example, if the survey has a subject matter, such as frequency of online purchases, that relates to presence in the web frame). If bias is suspected, it might be managed through poststratification, possibly based on information obtained in the telephone sample.

It is important to recognize that this approach is only defensible if one does not view the web sample as a convenience sample. Such a sample would result, for example, from using volunteer visitors to a web site as the sample. In the case of convenience samples, it has been shown that only in very special circumstances can a probability sample be used to correct bias in a companion convenience sample (Schonlau et al. 2002). However, web samples from opt-in lists or panels are not convenience samples in the usual sense of the term. The web frame may have serious shortcomings in regard to coverage and volunteerism, as already noted, but the selection of elements from the frame is done with probability procedures. Moreover, in the case of web panels, there is at least some effort at demographic representation.

As researchers gain more experience with web surveys, they will gain a better idea of the nature and severity of bias issues. Meanwhile, given the opportunity for cost savings, it seems that there is a role for the web in studies of rare populations, especially in conjunction with telephone or other methods.

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