



# Metrics and Design Tool for Building and Evaluating Probability-Based Online Panels

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## Abstract

Probability-based online panels are beginning to replace traditional survey modes for existing established surveys in Europe and the United States. In light of this, current standards for panel response rate calculations are herein reviewed. To populate these panels cost-effectively, more diverse recruitment methods, such as, mail, telephone, and recruitment modules added to existing surveys are being used, either alone or in combinations. This results in panel member cohorts from different modes complicating panel response rate calculations. Also, as a panel ages with inevitable attrition, multiple cohorts result from panel refreshment and growth strategies. Formulas are presented to illustrate how to handle multiple cohorts for panel metrics. Additionally, drawing on relevant metrics used for a panel response rate, we further demonstrate a computational tool to assist planners in building a probability-based panel. This provides a means to estimate the recruitment effort required to build a panel of a predetermined size.

## Keywords

web panel, probability-based panel, online panel, response rate, panel metrics

## Introduction

Online panels are widely used in social, medical, and psychological research (Callegaro, et al., 2014). Many national election studies are conducted with online panels (Clarke, Sanders, Stewart, & Whiteley, 2008), and research employing them is increasing every year, especially in the market research sector (Poynter, 2010). Building a probability-based online panel entails a series of design decisions that have a direct impact on cost, representativeness, attrition, and maximum number of survey completes.

Traditionally, computing a response rate for a survey has been a surrogate assessment metric for potential nonresponse bias in probability-based samples. This article will review current standards for response rate calculations. It is our position, however, that a response rate for a panel survey carries a heavier burden and that there are several levels of “response” addressed in our recommended

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calculation. The multiplicative function of that computation, which is presented in this article and updated since an earlier publication (Callegaro & DiSogra, 2008), raises the question of the meaningful utility of a panel response rate in light of the traditional interpretation. At the same time, the computational components to be discussed, such as a retention rate, are useful metrics for evaluating and maintaining a probability-based panel. These metrics can also be used for cost estimations, panel management and, as we will demonstrate, for calculating an initial sample size when building a new panel.

It is essential for the reader to understand the classification of online panels to appreciate the variety of components that influence a probability-based panel response rate. Online panels can be classed into the following two groups: the *volunteer nonprobability panels* (also called *opt-in panels* as their volunteer members proactively choose to join) and the prerecruited *probability-based panels* whose members are recruited using probability-sampling methods (Fricker, 2008; Sikkell & Hoogendoorn, 2008). The opt-in panels have no recruitment sample frame and thus a probability of selection from the population is unknown. Therefore the computation of a response rate is actually not possible; with no frame from which to be “selected” there is no definable denominator (American Association for Public Opinion Research [AAPOR], 2011). Moreover, the concept of a “response rate” for an opt-in panel sample can inherently hide a variety of potential survey errors. For example, a high survey completion rate reported for an opt-in panel sample might result from panel members who reliably participate in surveys—*assured responders*—having been placed into the sample by design (Bethlehem & Stoop, 2007).

Thus, how a panel is recruited defines it as a probability panel or not. We will discuss the trend in using one or more of a variety of recruitment strategies to build and to maintain a probability panel’s membership. These strategies result in multiple recruitment cohorts existing on a panel and therefore necessitate some proportional incorporation of their respective sample metrics when calculating a response rate for any survey using the panel. This proportional accountability will be demonstrated in this article with a weighted, multi-cohort, cumulative response rate formula.

A related component to consider when formulating a panel response rate is the panel’s attrition rate. Members of any type panel are expected to have some minimum tenure over time; however, attrition is inevitable. An attrition rate (or conversely, a retention rate) is an essential metric for panel management and maintenance and also for the quality of longitudinal study samples. Attrition reduces the number of panel members and can eventually limit the sample sizes that can be drawn from a panel. Membership attrition is generally never a missing-at-random (MAR) phenomenon, that is, some demographic groupings may attrite at a higher rate than others (Lugtig, Das, & Scherpenzeel, 2014). As it will be discussed, attrition is a problem for longitudinal studies because it produces cases with truncated or missing data. This can pose a threat to the validity of the longitudinal findings.

In this article, we limit our focus to response metrics specifically for probability-based online panels. Although the majority of online panels are nonprobability based (Callegaro et al., 2014), very recently, new research and non-profit probability-based panels have appeared or are being planned (GESIS—Leibniz-Institute for the Social Sciences [GESIS Panel, 2013]; GIP, 2013; Høgestøl & Skjervheim, 2013; Legleye & Lesnard, 2013; Martinsson, Dahlberg, & Lundmark, 2013; Nicolaas, Carderwood, Lynn, & Roberts, 2014; Pew American Trends Panel, 2014; University of Gothenburg Citizen Panel, 2014; University of Iceland Online Panel, 2014). At the same time, government statistical offices are building or planning to start probability-based panels (Amarov & Rendtel, 2013; Cobben & Bethlehem, 2013; Svensson, 2013). We are aware of two probability-based panels that either switched from nonprobability to probability recruitment (University of Gothenburg Citizen Panel, 2014) or had some earlier cohorts recruited with nonprobability methods, such as snowball and respondent-driven samples (Research and Development [RAND], 2013). The content of this article can be applied to samples from these panels when the sample is restricted to only its probability-based recruited members.

## Current Standards for Panel Response Rates

Current response rates developed for online panels tend to focus on the widely used nonprobability opt-in panels. In many cases, these standards do not explicitly make a distinction between opt-in and probability-based panels. In one of the earliest panel response rate discussions, the *Journal of Medical Internet Research* in 2004 suggested that opt-in panels avoid the term response rate altogether and instead use the journal's definitions of *view rate*, *participation rate*, and *completion rate* (Eysenbach, 2004).

Several documents specifically discuss response rate issues for online panels and offer a definition of terms. One such document entitled "Platforms for data quality progress: The client's guide to rapid improvement of online research" (RFL Communications, 2008, p. 1) was endorsed by the Market Research Association. *Response rate* is defined as "the total number of attempted responses divided by the total invitations/intercepts minus email bounce-back errors and requests for removal." *Completion rate* is defined as "the total number of surveys completed divided by the total number of cases passing the screening criteria."

Another document worth reviewing is the International Organization for Standardization (ISO) Standard 26362 (2009). Under the definition of incentive, this ISO states: "the term 'response rate' cannot be used to describe respondent cooperation for access panels."<sup>1</sup> Instead it defines *participation rate* as the "number of panel members who have provided a usable response divided by the total number of initial personal invitations requesting members to participate." The second edition of the ISO Standard 20252 (2012) introduces the term *penetration level*, which is defined as the "proportion of potential respondents or contacts who qualify to participate in a survey." Finally, European Society for Opinion and Market Research (ESOMAR, 2012) defines the three concepts of *start rate*, *participation rate*, and *drop-out rate* although no related formulas are given.

It seems clear that the terminology is not yet standardized and, more confusing, similar terms for these various rates have different calculations. The most detailed definitions for response rate and dispositions codes are published by the American Association for Public Opinion Research (AAPOR). In its seventh edition (AAPOR, 2011), the association tackles reporting response rates for probability-based Internet panels and nonprobability Internet panels drawing from Callegaro and DiSogra (2008). The authors define the concept and computation for recruitment, profile, retention, and completion rates. These four rates are shown to be components for computing a *cumulative response rate*. This cumulative response rate can only be calculated for probability-based online panel surveys because of the known denominator in the recruitment rate due to the known sample frame. Thus, the recruitment design of these panels is a key element of the response rate formulation.

## Probability-Based Panel Recruitment

When building a probability-based online panel, there are four recruitment design elements to address: recruitment mode/method, recruitment cohorts per mode, within-household selection of panel members, and methods used to involve (or not) non-Internet households. These all have implications for cost, management, and the calculation of a response rate.

**Recruitment methods: Single and multi-mode approaches.** An important design decision with implications (especially cost) for building a panel is whether to employ a dedicated or *direct recruitment* effort to place people directly into the panel or to use a *post-interview recruitment* to be added on to an existing survey effort. In the first case, a recruitment survey is conducted with the sole purpose of recruiting panel members. This is the strategy used to build the Gallup Panel. In a random digit dialing (RDD) outreach, sampled households are informed about the Gallup Panel. Those who express interest are mailed a "welcome packet" with instructions on how to enroll (Rooney,

Hanway, & Dillman, 2008). In the second case, a direct recruitment module is added to the end of an existing survey. Alternatively, one or two questions measuring general interest in “doing future surveys” can be added at the end. In this softer approach (no direct commitment to the panel), survey participants by default become panel members (preferably made known to them at some point). For example, the American Life Panel (ALP; RAND, 2013) in their recruitment cohorts, persons are asked if they would like to participate in “other research projects.” Those who expressed interest or possible interest were then re-contacted by a recruitment agent.

Probability-based online panels are generally built using offline recruitment methods, such as telephone, mail, or face-to-face. The former Knowledge Networks KnowledgePanel<sup>®</sup> (United States) originally recruited via traditional landline RDD but then switched to address-based sample (ABS) mail recruitment in 2009 (DiSogra, 2010; Gesellschaft Für Konsumforschung [GfK], 2013). This is a single focus, direct recruitment effort. The Dutch Longitudinal Internet Study for the Social Science (LISS) Panel was recruited in a multi-mode design. A sample was first drawn from the Dutch population register and an advance letter with an incentive was mailed. Household addresses with a matched telephone number were recruited by telephone, and the non-matched addresses were contacted in person (Scherpenzeel, 2011). The RAND ALP is an example of multi-mode recruitment methods where panel members come from eight different sampling and mode sources, some of which are not probability samples. The American Trends Panel (ATP) of the Pew Research Center (United States) was recruited in early 2014 with an add-on module to a large national cellphone and landline RDD telephone survey.<sup>2</sup> The advantage of this post-survey add-on is that the cost is already invested in the RDD survey effort and the panel recruitment piggybacks on that investment.

*Recruitment cohorts: Single versus multiple.* A single recruitment cohort exits when there is but one recruitment effort from a single recruitment sample. A recruitment cohort is made up of those sample units selected to be contacted with the purpose of recruiting panel members. Panels with a single recruitment cohort are built once. The longitudinal composition of the panel is determined by its attrition and panel life possibly set by a predetermined end date.

Multiple recruitment cohorts are a feature of an ongoing recruitment effort to build and maintain a large panel for an indefinite period or some predetermined lifespan. It might also be the case that multiple recruitment cohorts are a result of a periodic fielding strategy of replicate subsamples from single recruitment sample. Examples of a single recruitment cohort is the Face-to-Face Recruited Internet Survey Platform, FFRISP (Bishop et al., 2011), which recruited about 1,000 members in the summer of 2008, and the French Étude Longitudinale par Internet Pour les Sciences Sociales (ELIPSS) panel, which recruited 6,000 households in a single effort (Legleye & Lesnard, 2013). Examples of multi-cohort, continuous recruitment samples are GfK’s KnowledgePanel and The Gallup Panel.

The LISS Panel (Scherpenzeel, 2011) initially recruited about 5,000 households in 2007 as a single cohort design but then added three refreshment samples (2009, 2012, and 2014) and then an immigrant sample in 2010 (LISS Panel, 2014), making it a multi-cohort panel. A similar example is The American Panel Survey (TAPS) created by Washington University in St. Louis.<sup>3</sup> That panel is necessarily refreshed semi-annually with an additional, smaller cohort to maintain its size of about 2,000 members.

*Selection of panel members within households.* Once a household is contacted, there are at least three possible ways to recruit eligible panel members within a household when that household has more than one eligible person. First, randomly select *only one* eligible member of the household to join. Second, attempt to get *all* eligible members of the households to join (of which partial households can result due to non-cooperation). Third, allow only one household member to join based on some unique eligibility criterion.

An example of the random one-member-selection method is the 2008–2009 American National Election Survey (ANES) panel, which selected at random from an enumerated household a U.S. citizen, age 18 and older as of the upcoming election date (De Bell, Krosnick, Lupia, & Roberts, 2009). The household enumeration and random selection approach is challenging when it is not done by an in-person recruiter as in the ANES panel or by a telephone recruiter using computer-assisted telephone interviewing (CATI) technology. Recruiting by mail can also be done requiring a mail-back form with the enumeration information, which is then centrally processed to randomly select one person. This is then followed with a second mailing to inform the household which member has been selected. The TAPS panel member selection was done in this way.

Examples of a “whole household recruitment” are GfK’s KnowledgePanel and The Gallup Panel. Both attempt to recruit all individuals age 13 and older who reside in the sampled household. KnowledgePanel pays a per-person cash incentive for each eligible household member who signs up on the Web.

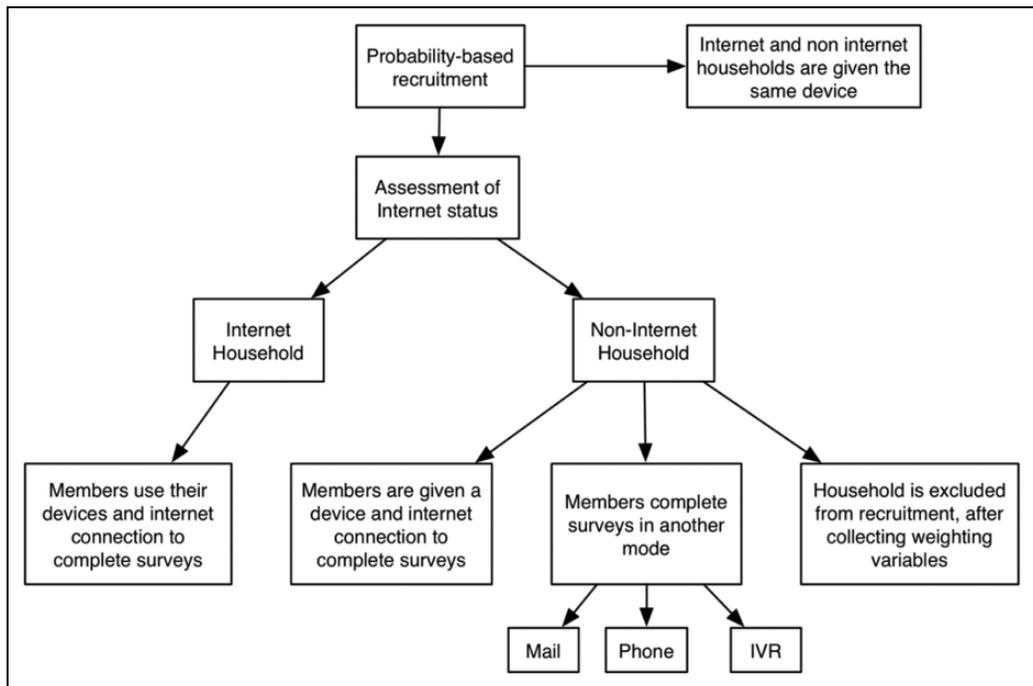
Another method of within household selection is based on a specific eligibility criterion, for example, the resident with the most recently celebrated birthday. Once the “recent birthday” member is determined, that eligible person is directed to the Web to join. Other examples of a pre-determined criterion used to select an individual within a household are head of household, major-purchase decision maker, or online entertainment viewer.

*Recruiting non-Internet households.* Building an online panel that is representative of the whole population of a country needs to address the fact that there will be households in the sample that do not have Internet access at the time of recruitment (see Figure 1). To achieve population representativeness, these households without Internet access should be included in the panel’s survey data. One option is to provide all sampled households with an Internet device whether they have Internet access or not. This was the original strategy of Knowledge Networks from 1999 until mid-2002 (Pineau & Dennis, 2004). Every recruited household was given a WebTV<sup>4</sup> and free dial-up Internet service. A similar approach was used by the now discontinued Dutch Telepanel (Saris, 1998), where households were given a desktop computer and a modem. In Italy, GfK was giving all recruited households a custom touch screen handheld device (called the *dialogue machine*) that enabled members to answer surveys via wireless mobile phone technology (Licastro, 2009). More recently, ELIPSS gave all panel members a seven-inch screen tablet with a data card (Legleye & Lesnard, 2013).

All options start with an assessment of the Internet status of the households targeted for recruitment. Once that has been established, one solution is to provide just the non-Internet households with Internet connection and a device. KnowledgePanel initially used WebTV but now provides a laptop only to its non-Internet panel members (GfK, 2013). The LISS Panel provides non-Internet households with a desktop computer called SimPC, a remote terminal with a simplified operating system (Scherpenzeel, 2011), while the German Internet Panel (GIP) provides a broadband connection and a special desktop computer called BenPC (Blom, Gathmann, & Krieger, 2013).

Another option is to collect the data using a non-Web mode, such as mail or telephone. This is the approach used by The Gallup Panel, which surveys non-Internet households usually via mail and occasionally via telephone and interactive voice recognition (IVR; Rookey et al., 2008). Other companies and countries handle non-Internet households in various ways: EKOS, a Canadian company, maintains a hybrid Internet-telephone panel called Probit, allowing these members to be surveyed via telephone<sup>5</sup>; the German GESIS Panel surveys via mail (GESIS Panel, 2013); and the Pew ATP uses a telephone interview or mail.

The final option is to exclude the non-Internet households from recruitment. This decision may be done for cost reasons and is possible in populations with very high Internet coverage where, perhaps, the coverage error due to excluding these households can be addressed with some type of weighting.



**Figure 1.** Possible major design decisions when building a probability-based online panel.

A study examining the exclusion of non-Internet households in a country with high Internet penetration is found in Leenheer and Scherpenzeel (2013). Although we are not aware of such panels at this time, this exclusion option is definitely a possibility as Internet penetration increases, especially with the proliferation of mobile Internet devices. This strategy is very similar to the one used at the start of landline telephone surveys, where the coverage error of the few households without phones was compensated by weighting (Keeter, 1995; Massey & Botman, 1988).

### *Multiple Stages in Computing Response Rates*

Probability-based Web panels are built in the following two stages: a recruitment stage and a profile (enrollment or connection) stage. In the first stage, the sample unit is contacted and, as per the eligibility criteria, either one or more respondents are recruited to be part of the panel. Depending on the mode of recruitment (face-to-face, telephone, or mail), a *recruitment rate (RECR)* can be computed using the disposition codes proposed by AAPOR in 2011. This is the first stage where nonresponse is introduced.

The recruited respondents express their intention to be a member of the panel, but eventually only a subset will become active members due to a variety of reasons (e.g., change of mind, problems connecting/receiving emails, etc.). Most panel companies send a *profile survey* to newly recruited members to collect basic demographic information and to welcome them to the panel. If potential members answer this survey or otherwise provide the basic information, they become part of the “active panel” and as such can be assigned to/selected for studies. Not every panel follows this exact procedure; some may assign new recruits to studies right away and then collect profile information as part of that first survey assignment or at some point subsequent to it. At the completion of this profiling stage, a *profile rate (PROR)* can be computed depending on the method and mode of data

collection. For example, the Gallup organization sends recruited households a mail questionnaire. Upon its completion, the household members who respond become part of the panel (Tortora, 2009). This profile stage also has a nonresponse dimension.

When a panel member is assigned to a study sample to complete a survey, a survey *completion rate* (*COMR*) for that specific study can be calculated. If mixed modes are used (e.g., a different mode for non-Internet households), then the survey completion rate has to be calculated separately for each mode and then combined for a weighted completion rate (weighted to the proportions completing the survey in each respective mode). This survey completion stage also has its own nonresponse component.

The multiplication of the three above-mentioned rates produces a cumulative response rate defined as *cumulative response rate 1* (*CUMR1*) and is represented as follows:

$$\text{CUMR1} = \text{RECR} \times \text{PROR} \times \text{COMR}.$$

A refinement on this cumulative response rate is to take into account the panel's *retention rate* (*RETR*). This is the proportion of panel members remaining on the panel at the time of survey sample assignment out of all panel members that had been successfully profiled (i.e., the retained proportion after attrition). *Cumulative response rate 2* (*CUMR2*) takes this retention into account and is represented as follows:

$$\text{CUMR2} = \text{RECR} \times \text{PROR} \times \text{RETR} \times \text{COMR}.$$

Details about these rates and calculating CUMR1 and CUMR2 can be found in Callegaro and DiSogra (2008). Lee (2006) and Hoogendoorn and Daalmans (2009) have studied nonresponse issues associated with each of these rates.

### *The Concept of Recruitment Cohorts for Panel Designs*

When there is more than one recruitment cohort, the computation of the different rates becomes more complex because, in a given sample selected for a study, there will be panel members coming from these different cohorts. When the specific study sample is drawn from only one recruitment cohort, the computation of the cumulative response rate is straightforward. This is, however, not the most common case. Many probability-based panels have continuous recruitment or periodic refreshment recruiting occurring over time.

The definition of a recruitment cohort depends on the panel organization. For example, in the original Knowledge Networks KnowledgePanel, a cohort was defined as the number of sample units that belonged to a sample replicate fielded weekly as part of an RDD sample (Callegaro & DiSogra, 2008). In the case of that panel's more recent address-based sample recruitment (DiSogra, Callegaro, & Hendarwan, 2010), the cohort is their sample of addresses used in each of the multiple recruitment mailings per year. For the LISS Panel, each recruitment effort is a cohort: the first recruitment, the refreshment samples, plus the 2010 immigrant sample (LISS Panel, 2014).

### *Computing Cumulative Response Rates with Multiple Cohorts*

To compute a cumulative response rate, it is necessary to associate each respondent to their original recruitment cohort. There are two possible cases: each respondent comes from the same and only recruitment cohort (the simplest case), or groups of respondents come from different recruitment cohorts. Either way, the computation follows these steps:

1. Identify the recruitment cohort of each respondent in the survey-specific sample.

2. Compute the cohort-specific recruitment, profile, and retention rates for each survey respondent's respective cohort.
3. Compute the weighted multiple-cohort recruitment, profile, and retention rates.
4. Compute the overall survey completion rate.
5. Compute the cumulative response rate.

To calculate Step 3, a weighted cohort average determines wRECR, wPROR, and wRETR as follows:

$$\text{wRECR} = \frac{\sum_{c=1}^k n_c \text{RECR}_c}{\sum_{c=1}^k n_c},$$

where  $c$  is the cohort (up to  $k$  cohorts);  $n$  is the number of study respondents belonging to a given cohort and,  $\text{RECR}_c$  is the recruitment rate for cohort  $c$ . A similar weighted cohort average computation is used to calculate wPROR and wRETR substituting  $\text{PROR}_c$  and  $\text{RETR}_c$ . The final product will depend on the diversity of the different cohort metrics existing among the cases in the final survey sample. Thus, a panel survey's cumulative response rate (CUMR2) would be calculated as follows with the final factor being the survey completion rate, COMR:

$$\text{CUMR2} = [\text{wRECR} \times \text{wPROR} \times \text{wRETR}] \times \text{COMR}.$$

### Panel Attrition Rates for Cross Sectional and Longitudinal Designs

*Typology of attrition.* We have discussed the importance of retention and how it is factored in the CUMR2 response rate. We now turn to the converse of retention: attrition. There are three kinds of attrition in online panels: voluntary, involuntary, and attrition due to ineligibility rules. Attrition is tied to the concept of active and nonactive panel members. Active panel members are those who are available to participate in surveys. When panel members are placed in a nonactive status, they are still counted in any attrition rate computation but are not sampled for specific surveys.

Voluntary attrition occurs when members contact the panel organization and ask to be removed from the panel. A similar case is when a panel member is placed in a requested temporary, nonactive status because of vacation, illness, or other personal reasons (temporary ineligibility).

Involuntary attrition occurs when the panel organization decides to change the status of some panel members to nonactive based on rules or policies. For example, if members do not respond to a specified number of consecutive surveys, they are placed on nonactive status. This action is common among online panels. Some members stop answering surveys without proactively communicating to the panel managers that they no longer want to be members. In practice, involuntary attrition is more complex. Think of it as a continuum, varying from loyal stayers at one end to early attriters/drop-outs (Lutgig, 2014) at the other end, with variations in between. Gradual attriters, for example, slow down their participation over time until they become *sleepers*, those who stop answering surveys for a period of 3 months or more (de Vos, 2008). Some of these sleepers can be reactivated with appropriate incentive mechanism, although a small percentage will voluntarily resume participation for the next 3 months or more (Scherpenzeel, 2014). There is also a class of attriters called *lurkers*, who do not follow a typical sleeper pattern of survey participation but instead demonstrate infrequent or periodic participation (Lutgig, 2014).

Finally, panel members become ineligible for a variety of reasons, such as moving outside the original sampling area (e.g., going abroad), having a situation that prevents them from regularly answering surveys (e.g., joining the military), or becoming physically or mentally incapacitated including death.

Because active status can be temporary or permanent, each of the described attrition typologies can have different outcomes depending on the time that they are computed. In the case of involuntary attrition, the panel organization might recontact lapsed panel members with the goal of convincing them to return to active status.

*Attrition rates for panel cross-sectional survey designs.* The attrition rate for a panel cross-sectional survey design is computed at a cohort level. Depending on the recruitment mode, the time of the recruitment and other variations in the recruitment effort (e.g., oversampling), each cohort ( $C_i$ ) will have its own unique attrition rate. The unit of analysis can be at a month level, for example, but other time references may be used. For this reason, Callegaro and DiSogra (2008) proposed the following similar formula for measuring the attrition rate at the month level ( $ATTR^m$ ):

$$ATTR^m = \frac{C_i^m - C_i^{m+1}}{C_i^m},$$

where  $m$  represents the starting month and  $m+1$  the following month. This same formula can be modified to address a different time period for attrition measurement. When considering panel members over time, the following formula is used to answer the question of what percentage of the overall number of active panel members ( $P$ ) is lost in a year due to attrition where  $y$  represents the starting panel size and  $y+1$  the panel size after 1 year. This is used in the following similar formula for measuring the attrition rate at the year level ( $ATTR^y$ ):

$$ATTR^y = \frac{P^y - P^{y+1}}{P^y}.$$

The overall number of active panel members at time  $y+1$  should not include the new recruits that joined the panel between  $y$  and  $y+1$ . Another way to express the same concept is to look at the probability of surviving 1 year on the panel (Sikkel & Hoogendoorn, 2008).

*Attrition rates for panel longitudinal designs.* When a subsample of panel membership (or more rarely the entire panel itself) is used in longitudinal designs, we can apply formulas from the literature of traditional household panels. At this time, however, there is no agreed-upon standard on how to report attrition rates. Attrition rates for longitudinal studies will be based on waves and not on a unit of time (e.g., months) as in the above cross-sectional survey design. Lynn (2005) provides the most thorough discussion on response rates for longitudinal design, and De Keulenaer (2007) offers an example applied to the Belgian household panel. For this article, we take Lynn's approach and produce formulas for attrition rates.

Before computing an attrition rate, it is important to note that there are two possible longitudinal designs. One design, an *unconditional invite design*, is where every member who was invited in an initial Wave 1 is invited in all subsequent waves independent of their participation in Wave 1. This is the most common design and produces a data set where there can be missing cases in each subsequent wave. In contrast, in a *conditional invite design*, using an example with three waves, only the members who responded to Wave 1 are invited to complete Wave 2, and only the members who completed Waves 1 and 2 are invited to complete Wave 3, and so on. As constructed, a conditional invite design produces a data set where there are data for all respondents across all waves.

The unconditional invite design can be used to produce the *maximum attrition rate* ( $ATTR_{\max}$ ). In this case, only those respondents who completed all survey waves ( $R_{All}$ ) are counted. If a respondent misses at least one wave, that respondent is counted as a nonrespondent or *attriter*.

$$\text{ATTR}_{max} = \frac{R_{W1} - R_{All}}{R_{W1}}.$$

Because of the  $R_{All}$  component, the above formula produces the same result for conditional designs as for unconditional designs.

The attrition rate between waves ( $\text{ATTR}_W$ ) looks at the number of respondents ( $R$ ) between two consecutive waves,  $Wt$  and  $Wt+1$ , and can be expressed as

$$\text{ATTR}_W = \frac{R_{Wt} - R_{Wt+1}}{R_{Wt}}.$$

With this formula, attrition matrices can be produced. In an unconditional design, the values from one wave to the next wave do not necessarily decrease because at every wave all baseline sample units are invited. In a conditional design, the values in the matrix will be at best the same if not lower when moving from wave to subsequent wave.

Finally, there is a *baseline-on-wave* attrition rate ( $\text{ATTR}_{base}$ ) that refers back to the number of respondents at Wave 1 as the base. This calculation is useful in determining the attrition for respondents at the time of any wave  $t$  ( $R_{Wt}$ ) relevant to the starting number of respondents in the base ( $R_{base}$ ):

$$\text{ATTR}_{base} = \frac{R_{base} - R_{Wt}}{R_{base}}.$$

### *Putting the Formulas to Work: Designing a Probability-Based Online Panel*

Given that many institutions are looking into moving surveys to probability-based online panels, we want to provide the reader with a practical application of the usage of our formulas in designing a probability-based panel in a specific country. What generally happens in events leading up to constructing a panel is the outlining of a pilot (see, e.g., Struminskaya, Kaczmirek, Schaurer, & Bandida, 2014) that can provide the necessary estimates to budget, build, and maintain a probability-based online panel.

The key concept in designing a probability-based panel is to use our formulas in reverse to produce an estimate of the initial sample size required for the first recruitment cohort, the timing between recruitment cohorts, and the size of the subsequent recruitment or refreshment cohorts.

The first step is to decide the maximum number of survey completes that can be supported by the proposed panel. For simplicity reasons, we assume that the largest study that can be done would be one that uses the whole panel (i.e., a panel census). This might, for example, conceivably be something like a completed survey size of  $n = 4,000$  cases. A parallel decision is to estimate the sample's design effect (*Deff*; Valliant, Daver, & Kreuter, 2013, p. 75) to estimate the effective sample size obtained after weighting those hypothetical 4,000 cases. This effective sample size is in practice what the researcher needs. For the sake of this example, assume a *Deff* of 1.25, which would result in an effective sample size calculated as  $n/\text{Deff}$ , giving us  $4,000/1.25 = 3,200$ .

The next estimates needed are the expected initial recruitment rate, the estimated profile rate, and for this example, the expected survey completion rate on the panel (a retention rate could also be estimated, but we forgo that here for simplicity). Let us assume an initial recruitment rate of 10% (e.g., coming from an ABS mail sample), a profile rate of 70%, and survey completion rate of 60%. The size of the probability recruitment sample to create this hypothetical panel with the specified necessary effective sample size is computed with the following formula:

$$\text{Recruitment Sample Size} = (n \times \text{Deff}) \times \text{COMR}^{-1} \times \text{PROR}^{-1} \times \text{RECR}^{-1}.$$

In our example, we would calculate the needed probability recruitment sample size as:

$$(3,200 \times 1.25) \times 0.6^{-1} \times 0.7^{-1} \times 0.1^{-1} = 95,238.$$

Thus, an ABS mailing (as an example) of at least 95,238 addresses would yield an initial panel completed sample size for its first survey of 3,200 cases. Clearly the calculation can be more complex and include more features to consider but this is the generalized concept.

The researcher may also need to add an expected percentage of ineligible cases to the initial recruitment sample to be fielded given that ineligibles are excluded from the response rate computation (AAPOR, 2011). Cost simulations can be added to prepare for possible scenarios. For example, recruitment with face-to-face interviewers are likely to get an initially higher recruitment rate but will cost more than a mail recruitment. A recruitment protocol added toward the end of a face-to-face or telephone interview survey is another strategy mentioned (i.e., post-interview recruitment add-on) and will have some expected impact on the initial recruitment rate.

Incentives (Callegaro et al., 2014) at the recruitment, maintenance, and survey completion stage are something else to take into account for increasing these rates. However, they will affect cost at each stage of the panel building exercise.

Finally, as soon as the panel is ready to be used for the first survey, it will be smaller than at its beginning. Attrition starts to reduce the panel size from day one and, unfortunately, the members who attrite do not attrite at random (Kruse et al., 2010; Lugtig et al., 2014; Tortora, 2009). The final effect of attrition, besides a lower number of available panel members, is a strain on the panel sample weights (these will increase for certain subgroups that have higher attrition rates) and will produce a higher design effect. Advanced planning with adequate supporting budgets for panel building, the cost to refresh cohorts, and panel retention strategies will keep the panel more balanced over time and demographically closer to the population it is intended to represent.

## Discussion

There is no doubt that significant resources are necessary to build a probability-based online panel. In addition to the infrastructure to contact and support panel members and effectively administer surveys on a modern technology Web platform (Macer, 2014), a methodology must be in place to recruit a representative panel. Obviously, the very essence of a panel is the composition of its membership since that is the source of the research information for which the panel exists. Therefore, we have identified elements of a panel's quality metrics that can be used to plan for the target panel size assuming it has a representative composition. By attaching expected metrics, such as a recruitment rate, profile rate, and completion rate, and considering a likely design effect, a recruitment effort can be confidently mounted. We have presented such a tool in this article. Of course, the methods and modes used in recruitment can vary, but it is assumed that they are only being applied to a probability sample. We also let the reader decide the design of that sample since populations and objectives will differ by situation and country.

Once a panel is built, membership retention and its converse, panel attrition, are critical to ensuring success and practical survival of the panel over time. Attrition undermines the representativeness, weighting, and variance structure of any panel data whether those data come from a survey of the entire panel or from smaller samples drawn from the panel. Thus, panel membership refreshment becomes a necessary operation to sustain panel composition and the generalization of survey findings. The appropriate measurement and thorough understanding of attrition guides the formulation of critical corrective and replenishment strategies.

The numeric interpretation of a response rate for probability Web panels is different than what we are accustomed to in traditional cross-sectional population surveys. A panel's response rate is uniquely a mathematical product of a multi-factor, cumulative operation. This produces a finite

upper limit on the range of what that rate will be. Single digit to low double digit rates are to be expected as the norm. These low rates should not be misconstrued as a sign of poor survey quality since this percent does not inform us as to the bias in the sample. The cumulative response rate we have described is meant to be a metric for comparing different panel surveys in conjunction with other methodological dimensions when assessing the quality of a survey, such as how R indicators are used (Schouten, Cobben, & Bethlehem, 2009). The importance of standardizing these metrics moves us closer to being able to do just that. Certainly, a relatively higher cumulative response rate is more desirable and, all things being equal, would positively correlate with better quality.

Given the surge in the number of probability-based online panels (e.g., GESIS Panel, 2013) and those being considered (Nicolaas et al., 2014) even in official statistical offices (e.g., Cobben & Bethlehem, 2013), we hope that this article may serve as guidance in informing design decisions in building these panels. Each decision has a cost impact associated not only in monetary terms but also in management and sample size terms. Figure 1 in this article visually represents the major design choices that should be considered.

The cumulative response rate concept can be used together with the attrition formulas as a means to estimate an initial recruitment sample size and related cost to build a probability-based panel to yield a target number of survey completes per interview cycle. This can be useful in planning particularly as institutions consider moving established surveys from other data collection mechanisms to probability-based Web panels (e.g., Nicolaas et al., 2014).

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### Notes

1. Access panel is defined as “sample database of potential respondents who declare that they will cooperate for future data collection if selected” (p. 1).
2. See <http://www.people-press.org/2014/06/26/appendix-3-about-the-surveys/>
3. <http://taps.wustl.edu/technical>
4. [http://en.wikipedia.org/wiki/MSN\\_TV/](http://en.wikipedia.org/wiki/MSN_TV/)
5. Probit. (2015). <http://www.probit.ca/what-we-do/probability-based-panels/>

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