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AMEE GUIDE

Improving response rates and evaluating nonresponse bias in surveys: AMEE Guide No. 102

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Abstract

Robust response rates are essential for effective survey-based strategies. Researchers can improve survey validity by addressing both response rates and nonresponse bias. In this AMEE Guide, we explain response rate calculations and discuss methods for improving response rates to surveys as a whole (unit nonresponse) and to questions within a survey (item nonresponse). Finally, we introduce the concept of nonresponse bias and provide simple methods to measure it.

Introduction

Surveys are a central part of medical education research (Artino et al. 2014). Successful surveys depend on adequate representation from the entire group being studied. The survey results may not correctly reflect the group's opinions if not enough people or a wide enough variety of people respond (Groves 2006).

Consider if 99 students in a class of 100 do not respond to a survey, the response from the one student who did respond cannot adequately represent the entire class of 100 students. Similarly, the characteristics of nonrespondents are as important as the total number of people not responding. Suppose the same class of 100 students is comprised of 50 females and 50 males; if all males responded but only 1 female responded, researchers cannot generalize the results of the survey to a broader female audience.

Thus, the number of people who do not respond and the characteristics of the people who do not respond can both impact the accuracy of survey results. It is in this context that we explore response rates and nonresponse bias, two related but separate concepts that are important for scholars who use surveys in their investigations.

Survey response rate refers to the percentage of potential survey respondents who actually return surveys (Dillman 2000a; Groves 2006). If a survey is not completed by enough people, it cannot represent the entire group. The concept of representative sampling depends on having a large enough sample. Thus, the response rate provides some information about how representative the survey is. Optimizing response rates is central to accurately describing the group of interest. The first part of this AMEE Guide explores reasons for nonresponse and methods for overcoming barriers to survey response.

Practice points

- Response rate is the percentage of potential respondents who reply to a survey. Nonresponse bias occurs when a characteristic of nonrespondents (e.g. age or sex) impacts the survey outcome because those opinions were not captured in the survey. Response rate and nonresponse bias are two different but related concepts.
- Scholars characterize nonresponse as either "unit nonresponse" (a person not participating at all in a survey) or "item nonresponse" (participant leaves at least one unanswered question on a survey).
- Cited methods of improving the response rate are providing advance financial incentives, sending at least three reminders, pre-notifying potential participants, and using different survey modalities (e.g. paper and email).
- Common ways to evaluate nonresponse bias are to:
  - Compare answers between early survey respondents and late survey respondents.
  - Compare demographic information between respondents and potential respondents.

The second part of this Guide explores nonresponse bias. Nonresponse bias occurs when the opinions from people who **did not** complete the survey are so different from those who **did** complete the survey that the results do not accurately represent the entire group of potential respondents (Dillman 2000a; Groves et al. 2002). Examining characteristics of the nonrespondents (such as the lack of female respondents in the

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introductory example) is important to predict nonresponse bias.

Defining response rate

Response rate is simply the number of people who responded to a survey divided by the number of total potential respondents. It is important that researchers clearly define how they calculated the response rate since different definitions can yield different results. The international community of survey researchers has endorsed using one of the six American Association of Public Opinion Research (AAPOR) definitions of response rate (Box 1) (Groves et al. 2002; AAPOR 2011; Johnson & Wislar 2012).

These six definitions differ by how they handle (1) partial responses (i.e. surveys with skipped questions (item non-response)) and (2) nonrespondents whose eligibility for participation is unknown (i.e. there is a list of potential respondents but it is unknown if all of the people on the list meet study inclusion criteria). AAPOR RR5 and RR6 are usually the best-suited definitions for medical education research. A detailed review of all six definitions is beyond the scope of this Guide, and interested readers are referred to the source definitions (AAPOR 2011).

The issue of unknown eligibility for nonrespondents is a significant concern in public opinion research but is less commonly encountered in medical education research. For example, if someone is trying to survey people on a street corner about what it is like to have children, only parents would be eligible to participate. The surveyor does not know, however, if an individual who walks by and ignores him is or is not a parent. Whether or not that individual should be included as a nonrespondent is handled within the definitions of the various AAPOR response rate definitions. Medical education researchers encounter this problem less often because they frequently have administrative records of their potential respondents, so they can approach only people who they know are eligible. See Box 2 for how to apply these definitions.

Defining survey and sampling frame

Two other definitions are important for understanding the rest of this Guide.

A "**survey**" refers to any tool directed at a select group of people that is used to gather opinions (AAPOR 2011; Artino et al. 2014). The "**sampling frame**" defines who the potential respondents are. For example, a researcher may send a questionnaire only to the first year medical students at a single institution. The sampling frame is thus only the first year medical students at that institution. A well-defined sampling frame is central to calculating a well-defined response rate because the percentage of potential respondents who returned the survey has meaning only if readers know who the potential respondents are.

Part one: Improving response rates

The potential respondents (sampling frame) can respond or not respond to the survey as a whole (**unit nonresponse**) or to just some of the survey questions (**item nonresponse**) (Dillman et al. 1993; Groves et al. 2002; Artino et al. 2014). An example of unit nonresponse is if a student immediately discards a questionnaire he received without making any mark on it. Conversely, an example of item nonresponse is if the student filled out and returned the questionnaire to the researcher but did not realise there was a back page with questions. The question(s) that the student skipped are considered item nonresponse. There are different causes of unit nonresponse and item nonresponse that we will discuss.

Unit nonresponse

Controllable factors that contribute to unit nonresponse (an individual not responding to the survey as a whole) generally fall into at least one of the following categories: survey delivery, survey acknowledgement, and the potential respondent's decision to participate (Dillman et al. 1993; Groves et al. 2002). This Guide will address each of these controllable factors respectively. Please see Table 1 for a summary of methods to increase unit response rates.

Survey delivery

The first part of the survey process is to effectively deliver the survey to the potential respondent. Each commonly used delivery method (email, fax, postal, etc.) has different reasons for delivery failure. For example, an email may not be delivered because of a typographical error in the address; whereas a postal letter may be lost somewhere in the postal mail system. Moreover, potential respondents may have different comfort levels with different survey methods, particularly electronic surveys (Groves et al. 2002; McMahon et al. 2003). Regardless of the reason, the mode of survey transmission can yield a different response rate (McMahon et al. 2003; Beebe et al. 2007).

Postal surveys appear to have better initial response rates than web surveys, even among computer literate college students using the internet for their classes in the USA as recently as 2011 (Millar & Dillman 2011). Of note, a single e-mail reminder raised the response rate of the web option to approximately that of a single-request paper questionnaire (51%) (Millar & Dillman 2011).

Utilizing both postal and electronic mail for surveys produces the highest response rates, as demonstrated in one study that found an absolute increase of 7.6% response rate (AAPOR RR1) among 500 paediatricians when they used the two modalities compared to only one survey modality (Beebe et al. 2007). Delivering a survey by more than one modality has the added benefit of including respondents with different preferences for survey methods. Surveys distributed by mixed modalities (e.g. email and postal mail) should be written with the exact same language and format for all survey modalities to minimize the impact of different delivery modality on item response (Dillman & Christian 2005).

Box 1. Response Rate (RR) Definitions and Example.

American Association of Public Opinion Research (AAPOR) 2011.

The 6 AAPOR definitions vary in how they treat partially and fully completed surveys and how they treat nonrespondents whose eligibility for the survey is unknown. For the example calculation, assume a medical school class of 150 student email addresses, from which researchers obtain: 50 completed surveys and 20 incomplete surveys. Of the remaining email addresses attempted, researchers had 15 refusals (students received and discarded the email), 10 non-contacts that were known to be eligible cases (e.g. invalid email addresses for registered students), and 5 invalid email addresses for MD/PhD students for whom it was unknown how many were eligible. In a prior study, only 40% of the MD/PhD students were in an MD year and therefore eligible.

Nonrespondent eligibility	Response Rate (RR) definitions	Example calculation	RR (%)
Assume that all nonrespondents with unknown eligibility are eligible	RR1 ''minimum response rate'': fraction of *complete* surveys over all other surveys and attempts $\mathrm{RR1} = \frac{complete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR1 = \frac{50}{(50+20)+(15+10+0)+(5+0)}$	50
	RR2: fraction of *complete and incomplete* surveys over all other surveys and attempts $RR2 = \frac{complete\ surveys + incomplete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR2 = \frac{50+20}{(50+20)+(15+10+0)+(5+0)}$	70
***Estimate* eligibility** for nonrespondents with unknown eligibility	RR3: same as RR1 but adds an estimate, $\boldsymbol{e}$, of the proportion of cases (MD/PhD students in this example) with unknown status that could not be contacted that prior research suggests will be eligible $RR3 = \frac{complete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +\boldsymbol{e}(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR3 = \frac{50}{(50+20)+(15+10+0)+0.4(5+0)}$	51.5
	RR4: same as RR3 but includes complete and incomplete surveys in the numerator $RR4 = \frac{complete\ surveys + incomplete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +0(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR4 = \frac{50+20}{(50+20)+(15+10+0)+0.4(5+0)}$	72.2
Eligibility known for all nonrespondents is known.	RR5: same as RR3 but assumes e=0 (thus improving the calculated response rate) $RR5 = \frac{complete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +0(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR5 = \frac{50}{(50+20)+(15+10+0)+0(5+0)}$	52.6
	RR6 ''maximum response rate'': same as RR5 but includes incomplete surveys in the numerator $RR6 = \frac{complete\ surveys + incomplete\ surveys}{\left\{\begin{array}{l}(complete + incomplete\ surveys)\\ +(refusal + noncontact + other)\\ +0(unknown\ if\ eligible + unknown\ other)\end{array}\right\}}$	$RR6 = \frac{50+20}{(50+20)+(15+10+0)+0(5+0)}$	73.7

Comment:
The first two AAPOR definitions (RR1 and RR2; RR, response rate) assume that all of the nonrespondents for whom eligibility is not known are counted as eligible. RR1 includes only fully completed surveys in the numerator. Partially completed surveys are counted as nonresponses. RR2 includes both fully and partially completed surveys in the numerator, which increases the response rate reported.
The second pair of AAPOR definitions (RR3 and RR4) estimates what percentage of nonrespondents with unknown eligibility were *probably* eligible. RR3 includes only fully completed surveys in the numerator. RR4 includes both fully and partially completed surveys in the numerator.
AAPOR RR5 and RR6 are usually the best-suited definitions for medical education research. RR5 includes only fully completed surveys in the numerator.
The AAPOR definition used should be stated in the manuscript with the response rate that authors provide. Simply writing ''X participants 'completed' the survey'' is unclear to readers.

Researchers should also be aware of some practical considerations for delivering electronic survey delivery methods since this differs from postal mail considerably. Respondents are increasingly accessing internet surveys from smartphones (Franko & Tirrell 2012; Millar & Dillman 2012). As of 2012, 88.4% of residents and 86.5% of fellows had smartphones in a large study of 678 institutions (Franko & Tirrell 2012). Survey administrators must keep in mind that offering an online survey means offering a survey that almost invariably will be accessed by computer, smartphone and

Box 2. Sample Calculation.

The following is an example calculation for AAPOR Response Rate Definitions 5 (RR5) and RR6. Suppose a survey is given to 100 total students, of whom 50 returned surveys with all questions answered and 25 returned surveys with only some questions answered.

$$\text{AAPOR RR5} = \frac{[50]}{100} = 50\%$$

$$\text{AAPORRR6} = \frac{[50+25]}{100} = 75/100 = 75\%$$

When presenting the data, we suggest the following:
''We obtained a response rate of 75% for the 100 potential respondents, AAPOR RR 6'' (AAPOR 2011).

Table 1. Controllable factors that can improve unit response rates.

Intervention	Situations when intervention is most useful
Mixed survey methods (e.g. internet and postal mail) (Beebe et al. 2007)	Reaching potential participants with varied experience or access to technology
Personalized survey invitations (Dillman 2000a; Edwards 2002)	Applicable to all
Monetary incentive (Church 1993; Asch et al. 1998)	Target populations that may need additional benefits to outweigh the benefit/cost ratio (e.g. clerkship medical students with limited free time)
Not providing an estimated survey time	Applicable to all
Survey less than 1000 words (Edwards 2002)	Applicable to all, but especially if participants may take the survey on a mobile device
Specific interviewer replies to initial refusals (Dijkstra & Smit 2002)	Potential participants who initially decline to participate
Repeated contact with potential participants (Lynn et al. 2002)	Potential participants who initially decline to participate
Pre-notification (Edwards 2002)	Applicable to all

tablet, which has extensive design implications discussed in the final section of this Guide (Buskirk & Andrus 2013). Also, regardless of the potential respondent using a mobile device or desktop, researchers must be sure to use a direct link to the questionnaire in any email or web invitation, so that the user does not have to cut and paste, but simply click the hyperlink to begin the questionnaire (Dillman 2000a).

Finally, most studies on the topic of survey delivery, such as postal mail or door-to-door surveys, use the general population (Dillman 2011). However, medical trainees represent a more captive audience than found in the general population (Groves et al. 2002). Survey delivery for medical trainees can be as simple as providing a paper questionnaire at the end of a class or residency program meeting where everyone is already assembled and attentive. This is in contrast to general community settings where surveyors are seeking potential respondents on busy streets or at their homes. As a result, the public opinion research on survey delivery methods may not be fully applicable to medical education researchers. Importantly, there is no medical education research to our knowledge about the bias of an authority figure directly distributing questionnaires to medical trainees, but anecdotally this is sometimes practiced to ensure high delivery rates. Researchers contemplating direct distribution by an authority figure to their trainees should discuss the method with their institutional review board (IRB) to ensure that it is considered ethical at that institution.

Survey acknowledgement

Survey acknowledgement – recognition by the potential respondent that s/he received a survey – is essential to achieve high response rates since potential respondents often do not even realize they received a survey. Approximately 10% of those in the general public who receive a postal mail questionnaire do not remember receiving it (Dillman 2000a). Personalizing the delivery and clearly stating the purpose of the mailing may improve acknowledgement by the recipient (Maheux et al. 1989; Dillman 2000b; Edwards 2002). For internet questionnaires delivered by email, for example, the survey should: include a clear subject line, be sent from someone the respondent knows (if possible), address the respondent by name in the salutation, and include a *brief* invitation to participate. A postal mail survey may be similar but with "important survey" written on the envelope rather than in a subject line.

Participant cooperation

A potential participant's decision to cooperate with researchers by completing the survey is a central component of the response rate achieved when considering unit nonresponse (people not participating at all in the survey). Factors that may influence potential participants' decision to cooperate can be conceptualized as controllable or uncontrollable by the researcher. Controllable factors can be accounted for in the initial study design, whereas uncontrollable factors cannot. The distinction is important because researchers can adjust the controllable factors mid-way through data collection if they need to attract respondents with demographics that are underrepresented in the survey.

Controllable factors

Controllable factors that influence whether participants respond include incentives, length of survey, psychological costs, authority and personalization, number of attempts,

survey timing and advance letters and reminders. Each will now be considered in turn.

Incentives

Studies in both the public sector and among physician respondents consistently demonstrate that monetary incentives included with the initial request significantly improve response rates (Berry & Kanouse 1987; Church 1993; Edwards 2002; Singer 2002; Keating et al. 2008). Although offering a lottery is better than not offering any financial incentive, the lottery does not fare as well as providing money (cash or check) directly *without requiring survey completion* (Edwards 2002; Robertson et al. 2005). Money also yielded better response rates than nonmonetary gifts such as food (Church 1993).

The minimum amount of monetary incentive needed to improve survey response rates remains unclear for medical trainees. The average value of monetary incentive offered to each potential respondent in the 1993 Church analysis was a mere $1.38 USD and provided an almost 20% absolute response rate increase, with a moderate effect size of $d = 0.347$ (Church 1993). Fully licensed physicians appear to require a larger financial incentive, however. A $50 incentive used in a survey study conducted in 2008 among colorectal surgeons produced a response rate of 67.8%, an absolute increase of 14.9% over the $20 control group (Keating et al. 2008). In contrast, Asch and colleagues obtained a response rate of 61% for $5 USD, which was significantly more than the 46% response rate with a $2 incentive of US primary care physicians in 1998 (Asch et al. 1998).

It should be noted that some researchers voice concerns about the unintended consequences of incentives, such as providing more optimistic responses or requiring incentives to participate in other, future surveys (James & Bolstein 1990; Shettle & Mooney 1999; Singer et al. 1998). However, several general population studies found no differences in survey answers. Studies that did find answer differences between those who did or did not receive an incentive found only more favourable comments specifically about the survey sponsor (James & Bolstein 1990; Shettle & Mooney 1999; Singer et al. 1998). Additionally, although people who receive compensation for completing a survey are more likely to agree with the assertion that people should receive financial compensation for completing surveys, they were in fact more likely to complete a survey without compensation six months later (Singer et al. 1998; Dijkstra & Smit 2002).

A practical recommendation for medical education researchers, who often work on a limited budget, is to consider sending a monetary incentive between $2 and $5 with the initial survey request that does not require completion of the survey to keep the money. Although this may seem counterintuitive to not require survey completion to receive the incentive, the aforementioned research provides evidence that providing the incentive before completion yields significantly higher response rates. The evidence is not clear, however, if the type of monetary incentive (cash currency, gift card, or cheque) makes a significant difference, and we recommend researchers tailor their monetary incentive to their specific resources and potential respondents.

Length of survey

Data from phone interviews suggest that not mentioning the survey length produced far greater cooperation than even mentioning short survey times [66% compliance versus 36% and 43%, respectively for no mention, 15 minutes, and 10 minutes in one study (Dijkstra & Smit 2002; Edwards 2002; Jepson et al. 2005; McFarlane et al. 2007)]. Several studies of mailed questionnaires to physicians and the general population confirm that shorter is generally better (Edwards 2002; Jepson et al. 2005; McFarlane et al. 2007). The odds ratio of response almost doubled (1.86) with shorter questionnaires in a BMJ study of various populations but did not clearly define short and long questionnaires (Edwards 2002; Jepson et al. 2005). Jepson and colleagues found a threshold for a mailed questionnaire to physicians of approximately 1000 words (38.0% vs 59.4%) (Jepson et al. 2005; Mavletova 2013). Moreover, length may be even more important in electronic surveys since surveys taken on mobile devices take approximately three times longer than surveys taken on computers (Dijkstra & Smit 2002; Mavletova 2013).

Psychological cost

Research on phone interviews suggests that mitigating objections can be helpful early in the interaction (Dijkstra & Smit 2002). For example, rather than the professional repeating, "You don't want to participate?" a response of "That's a shame; your participation means a lot to me," is more successful in getting potential respondents to participate in the survey. Although phone surveys may be less common in medical education research, this may translate to other modalities as well.

Personalization and authority

Utilizing a personal connection between the researcher and potential respondents also makes a statistically significant improvement (23% absolute response rate increase in one study) in response rates, compared to emphasizing authority from the sponsoring body, such as a university. This contrasts the prior dogma that advertising the authoritative nature of the sponsoring body was helpful (Maheux et al. 1989; Dijkstra & Smit 2002; Edwards 2002).

Personalization in emails, addressed envelopes and thank you letters may convince potential respondents to participate (Maheux et al. 1989; Edwards 2002; Lynn et al. 2002). For example, a researcher may write a personalized email to each potential respondent with their names in the salutation and a subject heading such as "An important study to improve your education."

The impact of authority on response rate and response validity remain to be clarified in the hierarchal world of medical education. Researchers who have direct authority over their potential respondents should be cautious and consider using a third party to administer the survey. Ethical considerations should be discussed with the IRB.

Number of attempts

Extended efforts (multiple attempts to obtain responses) by interviewers have long been described to improve response

rates, and newer public data suggest that the increased efforts may also reduce nonresponse bias (Dillman 2000a; Lynn et al. 2002). Finances and time invariably limit the number of contact attempts that researchers can make. Generally, three attempts are recommended based on cost/benefit analyses and general practices by surveyors (Dillman 2000a; Kellerman & Herold 2001; Willis et al. 2013). Researchers should also recognize that there is a difference in probability of eventually responding between potential respondents who were never successfully contacted (noncontacts) and potential respondents who were contacted but refused to participate. If there is no response after three attempts and the contact information is known to be valid, additional attempts will likely have a very low yield (Dillman 2000a; Hamilton 2003).

The optimal timing for reminders depends on the study. Approximately half of all responses tend to occur within one day of initiating a request and more than 90% tend to occur within two weeks (Hamilton 2003; SurveyMonkey 2011; Experian 2012; Mailchimp 2014). Researchers should take into consideration potential participants' schedules, such as exams, when planning the study period and sending reminders. We recommend a reminder interval between one day and two weeks, based on other timing conflicts the potential participants may have during that time period.

Survey timing

This topic is most salient for the email/web surveys since postal mail delivery is relatively unpredictable. The optimal time to send email/web surveys is unclear, even in the public sector (SurveyMonkey 2011; Experian 2012; Mailchimp 2014). Experian stratified the data and found that optimal times for opening email versus clicking to actually start surveys were different from each other. Prediction variables for both metrics were dependent on the industry (e.g. clothing, cleaning supplies, etc.) (Heberlein & Baumgartner 1978; Groves et al. 2002; Edwards 2002; Experian 2012). Thus, we have no specific recommendations for email timing for medical education researchers and offer it as an area ripe for research.

Advance letters and reminders

Advance letters announcing the survey, whether mailed questionnaire or in-person interviewer, are uniformly helpful in the public survey literature (Heberlein & Baumgartner 1978; Dillman 2000a; Edwards 2002; Groves et al. 2002). The pre-announcement typically arrives a few days before the survey.

Reminder communication has also been shown to increase questionnaire rates across the board regardless of modality. Whether paper or web, ease of use is important so the reminder should include another copy of the paper questionnaire or another link to the web questionnaire (Dillman 2000a; Johnson et al. 2002).

Uncontrollable factors

Gender

A study by McFarlane and colleagues looked specifically at the influence of physician respondent gender on probability of responding and found females less likely to respond initially, but that discrepancy was resolved with repeated survey attempts. The findings were repeated in other populations as well (Groves & Couper 1996; Groves et al. 2000; McFarlane et al. 2007). Thus, although the gender of each potential respondent is not controllable, the option to make repeated survey attempts is controllable and should be utilized to improve female representation in surveys.

Salience

Topic salience (relevance to an individual) can impact both unit and item responses. It is a central part of Groves' leverage-saliency theory and research supports that a topic's saliency can influence response rates (Groves & Couper 1996; Groves et al. 2000, 2002; NRC 2013). The leverage-saliency theory proposes that the decision to participate in a survey depends on a complex relationship between each potential respondent (such as likes, dislikes, time constrains, opinions about the survey topic, etc.) and the specific survey topic. For example, a student who was required to take a course may not find a survey about the course salient to his interests, leading him not to take the survey even if circumstances permitted time for him to take the survey. Not all circumstances can be controlled, but trying to create a connection between the respondent and the survey can positively influence response rates. Using the example above, the instructor may create a personal connection for the student with the survey by pointing out that survey responses will be used to improve the second part of the required course. In this case, the student will be directly impacted by the survey and has incentive to participate.

Interviewer

Research in the public sector has demonstrated a difference in response rates related to interviewers, especially interviewer experience (Groves & Couper 1996, 1998; Groves et al. 2002; NRC 2013). The reasons are complex, varying from interviewer confidence to ability to tailor the conversation to the potential respondent (Groves & Couper 1998; Durrant et al. 2010). Interestingly, interviewer scripts do not alter response rates for in-person interviews. The influence of the interviewer on response rate has not been examined in the physician literature, however.

Item nonresponse

This Guide will now turn from unit nonresponse to item nonresponse. Item nonresponse refers to a respondent either skipping a question or selecting "no opinion," "don't know," or "N/A" (Dillman et al. 2002; AAPOR 2011). Although the terms may not be entirely synonymous, we will use "no opinion" (NO) to represent the group of answers that represent a decline to respond, consistent with the survey literature.

A respondent's decision to skip or provide a NO response can impact the response rate, depending on the AAPOR definition used (Mason et al. 2002; AAPOR 2011). Regardless of the response rate definition used, a NO response represents a reduction in data that can be analyzed. Additional efforts to reach respondents may increase the total number of people

who respond but can also increase the item nonresponse rate. At least one study demonstrated that refusal conversions (potential participants who initially declined participation but eventually participated after further contact) skipped or provided NO for more questions than participants who did not have to be converted from refusal status (Beatty & Herrmann 2002; Mason et al. 2002). Bearing this in mind, researchers should still try to convince people to take the survey if they initially decline. Success with more total respondents must be measured by the full picture, which includes more skipped individual questions.

We divide this section by exploring why NO responses are given, then describe design techniques to minimize skipped questions, with special emphasis on internet questionnaires since they present unique formatting issues.

No-opinion (NO) responses

Beatty and Herrmann describe the decision to provide a NO response as based on cognition and motivation. Whether cognition or motivation creates more influence on the decision depends on the potential respondent and the question (DeMaio 1984; Beatty & Herrmann 2002). The term cognitive hindrance describes when a person cannot respond to a question because he/she simply does not know the answer. For example, asking a respondent how many times a day she is interrupted may represent a cognitive hindrance. The respondent can guess, but she cannot mentally calculate an accurate answer. A motivational hindrance, in contrast, occurs when the potential respondent knows the answer but does not want to provide the answer. Motivational hindrances can vary from the question being too long to asking a personal question that the respondent would rather not divulge to a stranger, such as a vice (DeMaio 1984; Beatty & Herrmann 2002; Krosnick 2002).

The NO option is intended to prevent forcing errors of commission that result when respondents without knowledge or opinion of a question provide essentially false information (Gilljam & Granberg 1993; Visser et al. 2000; Beatty & Herrmann 2002; Krosnick 2002). Thus, the NO option is intended as a caveat for cognitive hindrances, not motivational hindrances. Current recommendations from most survey researchers are not to provide a NO option for attitude and behavior questions. This is because research demonstrates that respondents' "leanings" toward opinions – even if they are not confident about those opinions – strongly predict real outcomes (Craig & McCann 1978; Bradburn & Sudman 1991; Gilljam & Granberg 1993; Visser et al. 2000; Krosnick 2002; Beatty & Herrmann 2002; Elliott et al. 2005). Decades of research repeatedly demonstrate that most of the time respondents check NO to attitude questions simply because they do not want to do the required cognitive work for the question or reveal an embarrassing response (Craig & McCann 1978; Bradburn & Sudman 1991; Dillman et al. 1993; Beatty & Herrmann 2002; Krosnick 2002; Elliott et al. 2005).

Providing a NO option for a cognitive question may be necessary, based on the question topic and potential respondent, but the question should define the desired accuracy of judgment so people feel comfortable selecting something other than NO if they are not absolutely certain about the answer (Craig & McCann 1978; Bradburn & Sudman 1991; Dillman et al. 1993; Beatty & Herrmann 2002; Redline & Dillman 2002; Elliott et al. 2005). Without explicit instructions, one respondent may select NO if she has any doubt whereas another may select NO only if she has great doubt about the answer.

Our recommendation is to determine why respondents may provide a NO answer and attempt to alleviate possible cognitive and motivational hindrances. Aside from strictly knowledge-based questions, survey writers should carefully consider if providing a NO option is worth the likely increase in item nonresponse.

Skipped questions

Generally speaking for surveys of any modality, survey length can be important to item nonresponse, although studies conflict (Craig & McCann 1978; Bradburn & Sudman 1991; Hox & de Leeuw 2002; Redline & Dillman 2002; Elliott et al. 2005). In general, surveys of any modality should be kept as short as possible to avoid survey fatigue and subsequent item nonresponse. In addition, cognitive and motivational hindrances can cause item nonresponse in any survey modality if a NO response is provided.

Postal and paper questionnaires

Respondent-friendly designs are important and improve item response on postal questionnaires. Design points include: (1) providing single-step instructions on a standard size sheet of paper, (2) avoiding extra papers such as inserts, (3) listing name (if necessary) and demographic information only once (rather than on each page), (4) using single sided forms, (5) allowing the use of any writing tool, (6) visually emphasizing the areas of the page that have the questions so respondents are not distracted by the optical scanner markings (Hox & de Leeuw 2002; Redline & Dillman 2002; Franko & Tirrell 2012).

It is well established that branching questions in paper questionnaires are associated with greater item nonresponse rates (Hox & de Leeuw 2002; Redline & Dillman 2002; Franko & Tirrell 2012; Buskirk & Andrus 2013). Although there are visual designs to reduce the nonresponse impact, we recommend against any branching questions on paper questionnaires. If a questionnaire requires branching questions, survey administrators should consider using a web-based questionnaire instead.

Face-to-face and telephone surveys

Few specifics are available to improve item nonresponse in face-to-face and telephone surveys other than the ability of the interviewer to persuade a potential respondent to answer all questions. We can only infer item nonresponse improvement from unit response research that interviewers who are confident and agree with the concept of persuasion garner better response rates for phone and face-to-face surveys (Hox & de Leeuw 2002; Franko & Tirrell 2012; Buskirk & Andrus 2013; Cullen 2013).

Table 2. Recommendations to improve item responses.

Tip	Rationale
Use a brief introduction (Dillman 2000a)	Respondent already read information about the study in the invitation to participate
Provide an easy, interesting first question (Dillman 2000a).	Motivates respondent
Consider a Personal Identification Number (PIN) to enter the questionnaire (Dillman 2000a)	Prevents people outside of the study from accessing it and makes longitudinal studies easier
Begin each question with a number and place the response to it as close as possible to the question (Dillman 2000a)	Questionnaires aligned as blocks tend to be distorted when converted to different sizes
Avoid excessive colour. Black on white is adequate (Dillman 2000a).	Overlay of text on colour can be distorted depending on the user's device palette
Separate each question/answer pair (Dillman 2000a)	Reduces wrap-around text and displacement of answer blocks that forces questions on top of one another
Consider a ''floating window'' accessible by touching or hovering the cursor over a question (Dillman 2000a)	Reduces propensity for wrap-around text and reduces total screen text. However, may not be viewed by everyone
Limit the number of drop-down box choices to a number visible at once on any screen (Couper et al. 2001)	The options first visible may influence respondents to choose those answers over those for which they must scroll to view
Minimize graphics and other features that increase page download time (Couper et al. 2001; Sue & Ritter 2012)	Longer download times are associated with greater survey abandonment
Include a simple progress bar (Couper et al. 2001; Sue & Ritter 2012)	Motivates respondents to continue, but not strong evidence. Progress bar may increase download time
Use closed-ended or short open-ended questions when possible rather than long, open-ended questions (Couper et al. 2001; Sue & Ritter 2012)	Longer entry time reduces item response rates
Do not require horizontal scrolling to view questions (Sue & Ritter 2012)	Difficult interface for respondents; confusion over which questions and answers correspond
Consider ''double banking'' or ''triple banking'' (two or three columns of answers, respectively) for lists of answers longer than a single screen view (Dillman 2000a; Sue & Ritter 2012)	Ensures that all possible answers have similar probability of being seen
Use Arial, Times New Roman, or Verdana fonts at 14 point (Sue & Ritter 2012)	Fastest and most accurate reading fonts

Web/email surveys

Web and email questionnaires are similar in that they are both electronic, but the steps required to return email surveys (clicking send rather than submit) can confuse some respondents (Dillman 2000a). Since smart devices are becoming more common, we recommend using email with a link to a web survey.

The web questionnaire visual interface is particularly challenging with the increased use of smartphones (Franko & Tirrell 2012; Buskirk & Andrus 2013; Cullen 2013). A web survey designed for a standard desktop computer will appear jumbled and can even have answer spaces associated with the wrong question. Thus, researchers must choose to:

(1) block mobile device users from accessing the desktop-formatted survey
(2) create additional surveys specifically designed for various mobile devices
(3) provide an internet version that adjusts to any device (responsive design)
(4) force mobile users to adapt to the desktop interface (not recommended) (Franko & Tirrell 2012; Buskirk & Andrus 2013; Cullen 2013).

The overarching principle for reducing question skipping on web surveys is ensuring the questionnaire is clearly visible for various interfaces. It is unknown which web browser is most commonly accessed by medical trainees, but in the general United States population it was Chrome (42.7%, Google, Inc., Mountain View, CA), Internet Explorer (25.4%, Microsoft Inc., Seattle, WA) and Firefox (20%, Mozilla Corporation, Mountain View, CA), respectively as of 2013 for a total of 88.1% of the total browser market (Franko & Tirrell 2012; Boudreaux 2013; Cullen 2013). The two most popular smartphone operating systems in a study of residents, fellows, and attendings in 2012 were iOS (48%, Apple Inc., Cupertino, CA), Android (19%, Google, Inc., Mountain View, CA) and Blackberry (13%, Blackberry, Inc., Waterloo, Ontario) for a total of 80% of the total phone market (Franko & Tirrell 2012; Boudreaux 2013; Mavletova 2013).

Web surveys should be built with these platforms in mind so as to reach as many respondents as possible. Some web questionnaire services, such as Qualtrics (Qualtrics, LLC, Provo, UT), offer interfaces designed specifically to work well in different sizes and on different platforms (Couper et al. 2001; Sue & Ritter 2012; Boudreaux 2013; Mavletova 2013; E. Hardle, personal communication, 7 September 2015), but no service as of this writing offered full "responsive web design." Responsive design allows survey designers to create one survey for internet use that ''responds'' automatically to any dimension and platform for optimized presentation (Dillman 2000a; Couper et al. 2001; Sue & Ritter 2012; Boudreaux 2013; Mavletova 2013).

We recommend using a survey service that offers a web interface that is designed to work well with most platforms and that surveys are tested by the questionnaire writers in all of the platforms. Use simple question layouts to avoid interface issues.

Branching questions in web surveys are unique in that with some services users are automatically taken to the appropriate next question. There is currently not enough literature on this topic to recommend for or against branching questions on internet questionnaires.

Another important consideration for web surveys is how many questions to put on each page. Adding pages increases the total survey time (Dillman 2000a; Couper et al. 2001; Sue & Ritter 2012; Mavletova 2013), which increases survey burden. However, a long page may leave the respondent lost on the page, especially if he is using a mobile device. Optimal page length and number of questions on a page is not clear, but the literature consensus is that multiple questions per page improves item response rates (Dillman 2000a; Couper et al. 2001; Groves 2006; Sue & Ritter 2012).

Additional specific tips to improve item response rates are listed in Table 2. Most are applicable to all types of questionnaires, while others refer to computer-specific graphics.

Part two: nonresponse bias

This Guide has outlined the two types of nonresponse and how to improve response rates. Now it transitions to nonresponse bias as a way to help the reader address concerns that arise when less than a 100% response rate is achieved.

Understanding nonresponse bias

As discussed in the introduction, survey accuracy is not only impacted by how many people do not respond, but the characteristics of the people who do not respond, such as age or sex. A response rate greater than approximately 60% was traditionally used as a marker to suggest a relatively low probability of nonresponse bias because it was assumed that there would be adequate representation of different respondent characteristics with so many people responding. We now know that the number of nonrespondents and the probability of nonresponse bias are very poorly related ($r = 0.3$) (Groves 2006; Halbesleben & Whitman 2013). Response rate and nonresponse bias are two different measurements, each of which provides different information to readers.

Nonresponse bias is a type of bias; it is present when a characteristic of the people who do not respond impacts what their answers would have been on the survey if they had responded. Put another way: nonresponse bias can only be present if the reason people did not respond has something to do with the questions being asked on the survey. Otherwise the reason they did not respond has nothing to do with the survey and should not bias the survey answers. For example, a study on the professionalism of being tardy is likely to have nonresponse bias from people who arrived late and never turned in a survey. The reason the people did not turn in the survey (they were tardy) was related to the survey's topic of interest (tardiness). **A relationship must exist between the reason people did not respond and the questions being asked on the survey**. Therefore, a low response rate does not in itself confer any bias. If the reason for the low response rate has nothing to do with the survey topic, then there should not be any bias. There must be a relationship between the reason for nonresponse and the survey, and the opinions of those who did not respond must differ significantly from those who did respond. This is a very different notion from previous conceptions of nonresponse bias.

Box 3. Factors Associated with Nonresponse Bias.

A. Factors Associated with Nonresponse Bias
- Respondent does not have a relationship with the sponsoring organization.
- Government sponsored surveys.
- Interviewer-administered questionnaires (compared to self-administered).
- General population (compared to specific populations).
- Attitudinal type questions (compared to behavioral and demographic questions).

B. Factors Not Associated with Nonresponse Bias
- Prenotification of the survey.
- Incentives to participate in the survey.
- Health topic (compared to other topics generally).
- Urban (compared to mixed locations of homes).
- Majority ethnicity (compared to minority ethnicity).
- Topic relevance to the potential respondent (topic salience).

Some nonrespondent characteristics tend to be associated with nonresponse bias more than other characteristics (Groves 2006). Authors should avoid the high-risk features when possible. Box 3 summarizes a recent meta-analysis (Groves 2006).

Calculating nonresponse bias

It is important to calculate a nonresponse bias since its presence can significantly impact survey results (Groves 2006). Researchers can appropriately adjust results if nonresponse bias is present.

It is impossible to calculate a true nonresponse bias since it is a number that does not exist. This is because if we obtain survey responses from the nonrespondents to see if their answers are different from the respondents' answers, the nonrespondents become – by definition – respondents. If we use alternative information about nonrespondents without receiving a response from them, then we are not truly analysing the subject of interest. **We must use either proxy data or proxy nonrespondents**.

Ways to calculate nonresponse bias can be conceptualized as either (1) measuring the variable of interest for proxy nonrespondents or (2) measuring supportive data (a proxy for the variable of interest) for the real nonrespondents. We recommend using one of each family of methods. There are several methods within each of the two families; here we discuss the most common ones (wave analysis, follow up analysis and evaluating supporting data). An alternative decision tree and examples of additional methods are also available (Groves 2006; Halbesleben & Whitman 2013).

Methods evaluating the variable of interest

Measuring the variable of interest among proxy nonrespondents allows researchers to calculate an actual nonresponse bias value. This is given by (Groves 2006; Jutel & Menkes 2009):

$$\text{Nonresponse bias} = (\text{proportion of nonrespondents}) \times \left[(\text{mean}_{\text{true respondents}}) - (\text{mean}_{\text{proxy nonrespondents}})\right]$$

The calculated nonresponse bias is essentially the difference in answers between the respondents and

Box 4. Calculating nonresponse bias and an example of wave analysis.

$$\text{Given that: Nonresponse bias} = (\text{proportion of nonrespondents}) \times \left[(\text{mean}_{\text{truerespondents}}) - (\text{mean}_{\text{proxynonrespondents}})\right]$$

Use wave analysis to calculate the nonresponse bias for a questionnaire sent to 100 people that asked how well AMEE Guides improve their research skills. The questionnaire is a single question using a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Twenty-five people responded to the initial request (first wave) with a mean score of 4.2; 25 people responded to the first reminder (second wave) with a mean of 3.9; 25 responded to the second reminder (third wave) with a mean of 2.7; and 25 people never responded.
(Hint: Remember to use just the first and last waves of responses. In this example, that is the first and third waves, and the third wave is the proxy for nonrespondents.)

$$\text{Nonresponsebias} = (\text{proportion of nonrespondents}) \times \left[(\text{mean}_{\text{truerespondents}}) - (\text{mean}_{\text{proxynonrespondents}})\right]$$
$$\text{Nonresponsebias} = (25/100) \times [4.2 - 2.7]$$
$$\text{Nonresponsebias} = (0.25) \times (1.5)$$
$$\text{Nonresponsebias} = 0.38$$

Explanation:
(Proportion of nonrespondents) is the fraction that did not respond; in this case: 25 people over the entire possible group, 100. The fraction is 25/100 = 0.25.
($\text{mean}_{\text{true respondents}}$) is the mean score of the people who responded in the first wave; in this case: 4.2.
($\text{mean}_{\text{proxy nonrespondents}}$) is the mean score of the group serving as the proxy for the nonrespondents, which is the third wave in our example; in this case: 2.7.
Interpretation: 0.38 on a five-point scale would likely be a concerning difference to the authors. (It is almost half way between two adjacent anchors such as agree and strongly agree.) A statistician should be consulted to appropriately adjust the reported result to weight against the nonresponse bias.

nonrespondents multiplied by the proportion of people who did not respond. Each researcher must examine results in the context of his/her research; no generally accepted cut-offs exist for acceptable amounts of nonresponse bias. There are several methods for calculating response bias using proxy nonrespondents; here we explore the more common ones: wave analysis and follow up analysis.

1. In wave analysis, late respondents (those who require reminders to respond) are proxies for nonrespondents. The responses in the last wave of surveys returned (such as after the final email reminder) are compared to the first wave of responses (such as the initial invitation to participate). This method uses late respondents as nonrespondent proxies and is a commonly used, simple, and well accepted method to evaluate nonresponse bias. Researchers can point to their wave analysis to directly demonstrate whether or not their study suffered from nonresponse bias. See Jutel and Menkes' article as a published, real data example (Doherty & Ellis-Chadwick 2003; Jutel & Menkes 2009).

2. Follow-up analysis is a common method in which researchers contact potential respondents in the sampling frame (population of interest) who are up to that point still nonrespondents and ask a very shortened survey, such as one or two most important questions, without demographic or other supportive information. The follow up respondents are considered proxies for the nonrespondents. Nonresponse bias is then calculated for the variable(s) asked of the (up to that point) nonrespondents. It is often difficult to obtain a large enough number of follow-up respondents amongst people who were already not responding to the survey. Nor is there a defined minimum number or proportion of follow-up respondents to analyse the data. Additionally, this method does not provide any information such as demographics or secondary survey questions to explain why the follow-up respondents are different from the original sample. In the wave analysis, researchers can look through the other supporting information available for all of the respondents, but not in follow-up analysis. A study by Doherty and Ellis-Chadwick is a good practical example of how to conduct a follow-up analysis (Doherty & Ellis-Chadwick 2003).

Methods evaluating supporting data

In contrast to methods that evaluate the variables of interest (e.g. wave analysis and follow-up analysis), methods that use supporting data do not calculate a mathematical nonresponse bias. Supporting data refers to information about respondents and nonrespondents other than survey answers, such as demographics (e.g. age). The population comparison method uses different sources for information about nonrespondents to compare demographic information between respondents and nonrespondents or between respondents and the entire population. For example, a researcher giving a survey to the entire first year medical student class could compare the proportion of female respondents against the proportion of females in the entire first year class, information that is typically readily available from the dean's office. See Avdeyeva's article as an example of the population comparison method (Avdeyeva & Matland 2013).

It is important to recognize that the population comparison method is NOT comparing the response rate between demographic groups of responders. A commonly employed, but not recommended, assessment for nonresponse bias is to compare response rates across demographic subgroups (e.g. whether the response rate for males was similar to the response rate for females). Comparing response rates across subgroups does not reflect nonrespondent opinions and should not be considered an evaluation of nonresponse bias.

Conclusion

Response rates and nonresponse bias are two different but related concepts. Both provide important information to readers about a study.

Researchers should strive for the highest response rate possible by carefully selecting the aforementioned methods to target potential respondents who are likely to have especially low response propensities. Monitoring response rates from demographic subsets during data collection can allow researchers to adapt communication methods to potentially reduce the potential for nonresponse bias. Response rates

should always be defined and reported using the gold standard AAPOR definitions.

Nonresponse bias should also be measured and reported using the two families of methods outlined in this Guide. Any nonresponse bias discovered should be evaluated with a statistician to potentially adjust the results appropriately.

Future survey method research in medical education should explore what response rates are achieved specifically among trainees and what characteristics predict survey participation within this highly specialized group. Examination of nonresponse bias present in our field's work to date will also be fundamental to interpret prior and future survey results, especially given how central surveys are to the medical education research platform.

Glossary

Survey: A set of structured or semi-structured questions conveyed in any format (paper, email, in-person, phone, focus groups, interviews) to better understand the sampling frame.
Response rate: Proportion of potential respondents who actually responded.
Unit nonresponse: A potential participant not providing any response to a survey.
Item nonresponse: Nonresponse from a participant such as selecting "no opinion" for a question or skipping the question (item) all together, but providing responses for other questions.
Nonresponse bias: A meaningful difference in at least one variable of interest between those who responded and those who did not respond; it is a type of survey bias.
Sampling frame: The scope of potential respondents from which the sample will be drawn. This may be the same as the population in a very small population, such as a single class at a single medical school.
Paradata: Information about how survey data was collected. Providing extensive paradata gives readers better context in which to interpret survey results.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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