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Studying Science Inequities: How to Use Surveys to Study Diverse Populations

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Abstract

Inequities in science have long been documented in the United States. Particular groups such as low income, non-White people, and indigenous people fare worse when it comes to healthcare, infectious diseases, climate change, and access to technology. These types of inequities can be partially addressed with targeted interventions aimed at facilitating access to scientific information. Doing so requires knowledge about what different groups think when it comes to relevant scientific topics. Yet, most data collections on science-based issues do not include enough respondents from these populations. The researchers discuss this gap and offer an overview of pertinent sampling and administrative considerations in studying underserved populations. A sustained effort to study diverse populations can help address extant inequities.

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Scientists in the United States have made transformative discoveries that have improved societal well-being. Yet, the United States also has a long, unsettling history of unequal access to these advances. This unequal access exacerbates disparate impacts of science related phenomena, such as climate change and COVID-19, on vulnerable populations. In part, these problems are exacerbated by the fact that research documenting inequities retrospectively is far more prevalent than research studying differences between groups prospectively. COVID-19 serves as a painful example: Had there been sufficient focus on minority and lower-income groups in studies of science communication, trust in science and vaccine messaging, interventions may have mitigated inequities in COVID-19 impacts. This is not to suggest that more study and data would undo the realities of structural racism and uneven living conditions, but it could provide crucial information to limit the multiplication of vulnerabilities.

We call on the social science community to invest more in collecting data on how various demographic groups in the U.S. understand, form opinions, and take actions when it comes to science and science related topics (also see Bilheimer and Sisk 2008, Welles 2014). Such data will facilitate the design of effective interventions so that people from different backgrounds can use science when it comes to health care, pandemics, climate change, the environment, energy, new technologies, food choices, and more. In line with this perspective, on their first day in office, the Biden administration established the Equitable Data Working Group, noting: "a first step to promoting equity in Government action is to gather the data necessary to inform that effort."

Unequal Impact and Attitude Variations

Those with low socio-economic status, minority groups, and other subpopulations face unique challenges in situations where access to science could prove essential. Consider climate

change. While almost everyone will be exposed to climate change impacts, certain sub-populations who are most sensitive to disturbances and least able to adapt to them will suffer most (e.g., USGCRP 2018: 548). These groups face more severe economic, infrastructural, health, and even crime consequences (Watts et al. 2018, White 2017). These same populations face distinct health threats. Here, racial, ethnic, and socioeconomic disparities have grown over the past forty years (Krieger et al. 2008), and these inequities will likely continue to increase due to emerging technologies, automation, and environmental hazards (Arcaya and Figueroa 2017). The devastating result of these health disparities is exemplified by the COVID-19 pandemic, with Black and Latino mortality 3 to 4 times greater than that for White Americans (Andrasfay and Goldman 2021). To get a sense of the scale, consider that, by one estimate, COVID-19 would need to cause 400,000 excess White deaths to equal the lowest mortality rate recorded for Blacks (Wrigley-Field 2020). Inequities also emerged during COVID-19 regarding economic hardships: in one state, Black adults were over 3 times more likely than Whites to experience food insecurity or unemployment while those without a college degree were twice as likely to experience food insecurity relative to those with some college (Perry 2021). In each of these circumstances – climate change, health, and COVID-19 – unequal access to science-based technology such as resilient crops and flood safeguards, medical screenings, and vaccines, contributes to the disparities.

A distinct type of disparity concerns variation in science literacy, interest, and attitudes. For example, while there is no gender gap in science ability or achievement early in life, women have less positive attitudes toward science and weaker science self-concepts later on (e.g., Weinburgh 1995, Jones et al. 2000). Additionally, racial and ethnic minorities often have significantly less confidence in science and are less scientifically literate (Plutzer 2013, Allum et

al. 2018). Religion is another factor that introduces heterogeneity into science opinions, with those who hold particular belief systems less supportive of certain types of scientific research (e.g., stem cell, nanotechnology) (Nisbet 2005, Brossard et al. 2009) and less trusting of scientists (Brewer and Ley 2013). Socio-economic status also matters with those at higher levels drawing more on ideological frames of reference (Ballew et al. 2020).

These experiential and belief inequities about science reveal that different populations need to be studied on their own terms. This is essential for the development of science-based interventions. Yet, there continues to be insufficient data on many of these groups. We focus on the collection of survey data, since such an approach allows for the standardized collection of information about different groups, across various topics.

Sampling Considerations

A first step involves defining the target population and then determining the feasibility of drawing a probability sample (i.e., every member of the group has an independent and identical chance of being sampled). Such samples can be extraordinarily costly, and thus, researchers increasingly instead rely on cheaper (but less accurate) non-probability quota sampling. This involves drawing a sample that matches key demographic benchmarks of the targeted population.[1]

A probability or quota sample requires that enough members of the group are available. For example, Pearson et al. (2021) compared the climate change beliefs of non-Latino Whites and Latinos by drawing a probability sample that included additional Latino respondents beyond the initial sample (i.e., an over-sample). This was possible because Latinos constitute a large

[1] Alternatively, some rely on pure convenience samples that do not match the population of interest (e.g., Amazon's Mechanical Turk). This approach is not particularly effective for sampling targeted subgroups unless is a purposive sample, as we shortly discuss.

share of the American population, and existing census data differentiating Latinos from non-Latinos allowed the researchers to identify the over-sample. To be clear, these samples are not without limits, due to limited coverage, non-response, and other errors, as are widely discussed in the survey literature (e.g., Marsden and Wright 2010).

Even so, members of many groups may be less inclined and/or able to participate in traditional surveys conducted via phone, the web, or in-person. This might stem from them making up a relatively small proportion of the broader population, and/or being difficult-to-reach. Examples of "hard-to-survey" groups include low income, young people, Indigenous people, and people in poor health (Tourangeau 2014). Yet, financial or logistical hurdles should not disenfranchise these populations. Instead, researchers can turn to alternative data collection approaches. While some of these approaches undermine the requirements of statistical inference to the entire relevant population, they nonetheless can provide crucial insight.

A first approach is list-sampling, where one obtains or constructs a list of group members from which to sample. For example, Wong et al. (2011) constructed a national list of Asian surnames to draw a sample of Asian Americans. Surname list approaches are common with even smaller racial minority groups such as Middle Eastern and Muslim Americans, for whom official population estimates are often lacking (e.g., Pew Research Center 2017). List-based approaches can leverage the plethora of data collected by market research, advertising firms, or professional organizations that maintain lists of individuals belonging to various groups (e.g., McCann and Jones-Correa 2016). For example, Hutchinson and Sutherland (2019) study college health providers, in part, by drawing a sample from a professional organization's mailing list. This ensured coverage of smaller, private colleges. They find providers from such schools do not differ from others in terms of screening female students who have experienced violence.

Another list-based approach uses administrative records. For instance, the New Immigrant Survey (1996-2009) used U.S. Immigration and Nationalization Services (INS) records to field a probability based, longitudinal study of legal immigrants and their children in the U.S. (Massey 2011). Others utilize voter registration records where, in some states, the race/ethnicity of registrants is collected, or is identified by researchers based on the registrant's name. Creative applications of list sampling can generate probability samples of the targeted group (see, e.g., Wong et al. 2021; also see Barreto and Segura 2014).

Second, one can employ density sampling, which is a type of stratified sampling where one selects geographic areas known to have a high proportion of the population (based on the Census) and then samples from within those strata. For instance, the National Study of American Life sought to include a sizeable Afro-Caribbean sample and thus over-sampled from geographic areas known to have high concentrations of that population (e.g., New York, New Jersey, District of Columbia, Florida). This enabled them to identify a relatively low incidence of care for major depressive disorders among that group (Williams et al. 2007).

It is worth mentioning too that list and density sampling techniques are frequently used in tandem, particularly when constructing samples of racial and ethnic minority groups (Barreto et al. 2018). List sampling ensures at least some coverage of group members who do not reside in ethnic enclaves, while density sampling provides coverage of group members who may not have ethnically distinctive names, participate in ethnic affinity groups, or have otherwise been identified. These combined techniques mitigate systematic bias associated with a single approach and ensures better coverage of the population of interest (see Berry et al. 2016).

A third approach is purposive sampling. Here, expert judgment allows researchers to choose locations, given their aims. For example, McCloud et al. (2019) assessed cancer

incidence in the state of Massachusetts with a hybrid probability/quota internet sample. They worried though that this approach would underrepresent low socioeconomic individuals, due to a lack of reliable internet access and distrust of the research institutions who oversaw the study. The researchers thus collected a purposive sample, working with community groups to identify locations to reach those of lower socioeconomic status in-person (e.g., community centers, soup kitchens, public libraries). Their community-based purposive sample included substantially more low-income, less educated, and racial minority respondents who exhibited differences, including less adherence to colorectal cancer guidelines and much greater difficulty in obtaining health information. The authors point out that "without the purposeful oversample… we would been underpowered to detect important differences between groups" and these people "may otherwise not have a voice" (439-440).

Fourth, in snowball sampling, the researcher utilizes participants to recruit others. For example, Tang et al. (2021) sought to study differences between those quarantining in different geographic locations during COVID-19 in China, a hard-to-reach population. The researchers contacted individuals in quarantine in strongly affected areas, in quarantine in unaffected areas, and people not in quarantine. They asked the first 10 respondents of each group to provide social contacts (from the same population), and then randomly chose to use the lists provided by the second and third respondents of each group. They surveyed those lists, asking each new respondent to produce lists as well. This approach provided the researchers with sufficiently sized samples, from which they report evidence that quarantining leads to higher rates of depression, particularly when in unaffected areas.

Finally, respondent driven sampling (RDS) follows a similar procedure as snowball sampling, with initial participants providing recruitment information from a set number of their

peers (Heckathorn 1997, Salganik and Heckathorn 2004). Unlike snowball sampling, RDS asks respondents to provide information about how many people in the target population they know and who know them. Researchers then use these identified connections to weight respondents, such that those with more connections, who have a higher probability of being sampled, are weighted less and those with fewer connections are weighted more. In addition to hard-to-reach populations and stigmatized groups, RDS is often used to sample extremely rare or small populations for whom traditional techniques would be cost prohibitive (Giles and Handcock 2010), such as Korean American immigrants (Lee 2020) and adolescents living in economically distressed urban settings (Decker et al. 2014). Using RDS, Decker et al. (2014) find nearly 10% of economically distressed adolescents report having unstable housing and nearly 30% report high levels of school truancy.

While some of these approaches preclude inferences to the entire population of the given group, they still can produce vital information to facilitate crucial interventions.[2] Nearly every example reviewed reveals non-trivial disparities among a differentiated subgroup that, even if one cannot infer the percentages, suggests the need for interventions. Many of the examples concern health – scholars have done more work on disparities in health than other science areas (e.g., climate change, energy, new technologies) – but, given the previously identified inequities, more work is essential in these other domains. Notably, scholars have moved towards combining multiple sampling techniques to mitigate the limitations of any single approach. This might involve oversampling racial minority groups through a combination of panel recontacts and

[2] Respondent driven sampling is sometimes portrayed as extremely accurate; however, Goel and Salganik (2010) show that, in most applications, it is not.

newly recruited respondents, using random digit dialing (RDD), address-based sampling (ABS) of high-density areas, and lists (PRRI 2019; Pew Research Center 2011, 2012).

Survey Implementation

Studying targeted groups requires attention to unique implementation and measurement considerations. First, language is an important consideration in securing participation and minimizing measurement error in responses for non-English speaking respondents or those for whom English is not their first language. This can involve many languages; for instance, one survey focused on new immigrants was translated into 8 languages and administered (via phone) in over 80 languages (Smith 2010: 744). Translation involves more complex processes than one might assume. At a minimum, a quality translation requires one translator adapts the original questions to the target language, another translator retranslates the survey to the original language, and researchers compare the two, working with the translators to resolve differences (Cantor et al. 2005). More elaborate processes that involve people from the target communities produce even more accurate translations (Smith 2010: 746-747).

A second consideration is the survey mode – that is, whether respondents participate in-person, via telephone, or through the mail, e-mail, or on the web (Tourangeau 2018). Given the inherent difficulty of collecting data from targeted subgroups, scholars need to consider how a given mode affects recruitment and response. An appropriate mode enhances personalization and legitimacy, and minimizes cognitive burden (Tourangeau 2000). For instance, the previously described McCloud et al. (2019) study targeted low income, blue-collar, homeless, African American, and Latino respondents. They conducted an in-person study at community sites, which personalized the process. and established legitimacy. Additionally, cognitive burdens were minimized by "going to" the respondents, offering English and Spanish versions, and having

them compete the survey on paper, rather than computers, which may be less familiar. Such steps often must be taken when the target population includes lower income respondents who frequently move, and often have low trust in strangers and the government (Weiss and Bailar 2002). Careful selection of mode and location can also facilitate sampling of targeted groups. For instance, Barreto and Dana (2019) surveyed American Muslims in an "exit-poll" fashion by recruiting respondents in-person at religious sites following Eid prayers and celebrations. Their choice of location and mode (self-administered paper surveys handed out in person by Muslim interviewers) encouraged trust and compliance among the targeted population.

Mode matters for other groups, too. For instance, younger respondents tend to register more item-non-response in on-line surveys than phone surveys (Bowyer and Rogowski 2017) and Native American respondents tend to roll-off in survey involving mail (likely due to low levels of mail coverage in Native American communities) (González-Cabán et al. 2007). As with sampling techniques, many firms are now moving to multi-mode administration that combine telephone and online administration. A 2018 UCLA study found that a multi-mode (address, mail, internet) approach had key advantages over single-mode administration. However, telephone follow-ups were crucial to obtaining samples of small and disadvantaged groups, such as older, less-educated, non-English speaking, and foreign-born participants (Wells et al. 2019).

Related to mode and language considerations is the issue of interviewer identity. Extensive research has documented the impact of the race of the interviewer, particularly co-ethnic interviewers, on survey responses. Recent studies show important differences in attitudes and behaviors, including self-reported voting, when Black respondents are interviewed by fellow Black people versus non-Black interviewers (Laird and White 2020; Jenkins et al. n.d.).

A third survey administration dynamic with targeted populations concerns variations in perceptions and/or understandings of meanings. For instance, many science surveys ask respondents to rate their concern about the environment. Yet, it turns out that "the environment" carries distinct connotations to different groups. Song et al. (2020) show that non-White and low-income respondents have a broader conceptualization of environmental issues than White and high-income respondents. Blacks and Latinos are significantly more likely to identify poverty, unemployment, diabetes, and racism as environmental, while lower-income individuals are significantly more likely to identify unequal access to education and racism as environmental. Moreover, those living in lower-income zip codes are more likely to identify drug abuse, smoking, and unequal access to education as environmental. Consequently, when surveys ask respondents about their attitudes on environmental issues, different groups clearly think about different issues. This poses substantial interpretation challenges for research on environmental and science attitudes, particularly since many of these differences align with features of populations that make them vulnerable to different environmental threats.

Along similar lines, groups view the term "science" differently. Abrams and Middleton (2017: 168) captures this dynamic: "science knowledge lives in the beliefs and practices of individuals and communities rather than as a body of decontextualized knowledge. Embedded science knowledge may take many forms, including the wisdom and understandings that individuals develop over time…" A concrete example concerns variation due to religiosity. More than half of atheists think that religion and science are incompatible, while only 9%-14% of believers see that incompatibility (Baker 2012). Thus, inquiring about science (e.g., science

funding) may bring forth very different mindsets depending on the target population (e.g., what is included in "science" funding).[3]

Survey designers also must ensure they are including all relevant measures. Pearson et al. (2021) demonstrate that Latinos based their climate change beliefs on familism, rather than ideology and education; this counters the prevailing wisdom about correlates of climate change beliefs (e.g., Hornsey et al. 2016) and shows that studies must measure what matters to this subgroup. Similarly, Smith et al. (2014) find a key correlate of support for climate change policy among Native Americans is a belief that God created the earth, while, interestingly, this relationship was reversed among ranchers. Finally, those with lower socio-economic status rely much more on interpersonal sources for science and health-related information, thus accentuating the need to incorporate social network measures that isolate the likely sources (Kontos et al. 2011).

In sum, collecting data from targeted groups introduces administrative considerations that differ from general population surveys. Most data sets on scientific topics are designed and implemented by researchers/scholars. For example, a team of professors and survey experts, supported by an academic board of overseers, lead the Science Module on the General Social Survey. While this structure makes sense for many surveys, a science survey for targeted populations should enlist the help of individuals who represent and/or work with the targeted communities to ensure that survey questions are understood by respondents and include response options which capture likely attitudes and behaviors. Boundary-spanning organizations can provide appropriate context and insight into relevant constructs survey question design. Research-practitioner partnerships with these organizations can be leveraged, not just for data

[3] Another example is Schuldt's et al. (2015) well-known finding that Democrats view "global warming" and "climate change" as synonymous, while Republicans view them as distinct.

collection (e.g., to establish legitimacy), but also for providing data to researchers, librarians, museums, authors, health care workers, etc. to engage different communities. This type of data collection partnership re-defines common roles that typically involve researchers that collect and analyze data, and boundary-spanners communicating, translating, and mediating (Safford et al. 2017). Here, instead, the design and implementation would bring together these groups to maximize the impact and usage of a targeted population science data set.

Conclusion

Science can be thought of as a public good, and as such, inequities in access to science is inherently unjust. Dietz (2013: 14082) highlights the benefits of science: "a good decision must be factually competent. The beliefs used in making decisions should accurately reflect our understanding of how the world works. Here, the role of science is obvious: Science is our best guide to developing factual understandings." Effective public engagement with science requires a strategic approach that targets opportunity to engage, capacity to engage, and motivation to engage (Michie et al. 2011). Therefore, to ensure the engagement of diverse audiences, we must collect data on the opportunities (e.g., access), capacity (e.g., science literacy), and motivation (e.g., expectations of science) of these groups. Having these data will allow us, as citizens, practitioners, researchers, policymakers, and advocates, to make sound decisions about where to invest and how best to improve engagement among diverse segments of the population.

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