Journal of Traumatic Stress, Vol. 19, No. 2, April 2006, pp. 185–193 (© 2006)

Web-Based Methods in Terrorism and Disaster Research

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This article provides an overview of the use of the Internet for conducting studies after terrorist attacks and other large-scale disasters. We begin with a brief summary of the scientific and logistical challenges of conducting such research, followed by a description of some of the most important design features that are required to produce valid findings. We then describe one approach to Internet surveys that, although not perfect, addresses many of the challenges well. We close with some thoughts about how the Internet-based methods available today are likely to develop further in coming years.

Conducting methodologically rigorous studies of responses to disasters and other traumatic life events is extraordinarily challenging in several important ways. Research in the natural laboratory is typically expensive, labor-intensive, and time-consuming (Silver, 2004). Obtaining external funding—particularly quick-response funding after a national or community disaster—is often difficult. Gaining access to samples of traumatized populations can be challenging, and access to entire groups of traumatized individuals is sometimes restricted. Additionally, institutional review boards (IRBs) are often appropriately (but sometimes inappropriately) uncomfortable with trauma-related research.

As a result, many studies of disasters have been conducted with small, nonrepresentative samples of individuals who were available and were willing to answer sensitive questions posed by a stranger. Additionally, other studies have been conducted within clinical settings with individuals who have sought professional help for their mental health or other symptoms. The conclusions drawn from such studies, however, do not readily generalize to the broader population.

The design and implementation of research after major disasters and terrorist attacks thus present formidable scientific and logistical challenges, many of which result from the fundamental unpredictability of these events. This article addresses the use of Internet-based approaches to community epidemiologic studies after such events. Although clearly not a cure-all, use of Internet-based methods provides at least partial solutions to some of the important challenges. In what follows, we identify some critical challenges for epidemiologic studies of major disasters or terrorist attacks, discuss how Internet-based studies can reduce them, summarize briefly some of the advantages and

A condensed version of this article appears as W. Schlenger and R. C. Silver, (In Press) Web-Based Methods in Disaster Research. In F. Norris, S. Galea, M. Friedman & P. Watson (Eds.) *Methods for Disaster Mental Health Research* © 2006 The Guilford Press. Reprinted with permission.

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drawbacks of Web-based studies, and provide some details of how such studies can be implemented.

CHALLENGES OF STUDYING THE AFTERMATH OF MAJOR DISASTERS AND TERRORIST ATTACKS

Community epidemiologic studies in the aftermath of disasters and other large-scale traumatic events today typically involve surveys conducted with probability samples of a specific population (e.g., people living in the neighborhood or city in which the event took place, the U.S. population). These surveys are aimed at estimating the prevalence and/or incidence of one or more specific conditions and of important comorbidities, identifying specific "risk" or "protective" factors that convey vulnerability or resilience, and so forth. The prevalence (i.e., proportion of a specified population who have the condition of interest in a specified period) of posttraumatic stress disorder (PTSD) and that of associated risk factors have been relatively well documented in community studies that cover a broad range of potentially traumatic events (e.g., Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995) or that focus on a specific event (e.g., Norris & Uhl, 1993). The incidence (i.e., proportion of a specified population who have a new onset of the condition of interest in a specified period) of PTSD and its course, however, have been less well studied. Additionally, the relationship of PTSD to other psychiatric and substance use disorders has also been relatively well documented, but less attention has been paid to other potentially important comorbidities (e.g., chronic health conditions).

The primary scientific and logistical challenges of conducting such studies, however, result from the unpredictability of the exposures of interest, i.e., the fact that terrorist attacks, disasters, and other large-scale traumatic events typically occur with little or no warning. North and Pfefferbaum (2002) have identified a number of issues involved in conducting such studies and offer helpful guidelines and recommendations.

Additionally, Schlenger, Jordan, Caddell, Ebert, and Fairbank (2004) provide a more detailed explication of some of the important issues. They note that some of the more challenging design problems arise from two characteristics of studies of sudden and unanticipated large-scale traumatic events: the necessarily observational nature of the studies and the need for them to be designed and implemented quickly. The studies are observational because researchers cannot (and, we hope, *would* not) randomly assign people to exposed versus nonexposed conditions. This necessary lack of random assignment limits the ability to draw causal inferences about the link between exposure and observed outcomes.

Further, the unpredictability of these events often results in the studies being post-only designs—i.e., designs in which all assessments are conducted after exposure to the event (see Silver, Holman, McIntosh, Poulin, & Gil-Rivas, 2002, for a recent exception, and Bromet & Dew, 1995, for others). Post-only designs provide limited ability to rule out preexisting symptoms or previous exposures as potential explanations of the study findings. Additionally, they open the door to confounding of symptom reports with exposure levels, which also weakens the ability to draw causal inferences about the exposure (see Silver et al., 2006). When designs are both observational and post-only, inferential power is further eroded.

The need for rapid response that arises from the unpredictability of the exposure and the desire to document both degree of exposure and postexposure adjustment as fully and accurately as possible create both scientific and pragmatic challenges for the research team. For example, assessments of specific features of an individual's exposure are most accurate when made with little time lapse between the exposure and assessment. Doing so, however, requires mounting a major field data collection effort, including developing assessment interviews and sampling plans, hiring and training interviewers, etc., in days or weeks rather than months or years.

The need for rapid response after disasters has pushed the field in recent years away from traditional in-person survey interview methods and toward data collection methods that can be implemented quickly, such as telephone surveys and Internet-based surveys. In addition to reducing the elapsed time between exposure and assessment, use

of these methods allows the findings to be published in the literature more quickly. For example, papers describing findings related to the car bombing of the Alfred P. Murrah Federal Building in Oklahoma City in April 1995 began to appear in the literature in 1999 (North et al., 1999) and were based on in-person interviewing. Conversely, four papers (Galea et al., 2002; Schlenger et al., 2002; Schuster et al., 2001; and Silver et al., 2002) describing reactions to the September 11, 2001, terrorist attacks appeared in top-tier health journals in the first 12 months after the attacks; all four of these studies used either telephone- or Internet-based survey methods.

Moreover, the threat of future terrorist attacks and the likelihood of future community disasters demand that a higher level of urgency and research sophistication be directed at understanding the psychological effects of such events over time. As noted by others (Norris, Friedman, & Watson, 2002), empirical evidence concerning the adjustment process after disaster exposure can aid clinicians by identifying potential risks and may facilitate the design of interventions for individuals coping with negative outcomes.

HOW USING THE INTERNET CAN ENHANCE DISASTER STUDY DESIGN

Despite the scientific and pragmatic challenges, it is important that disaster and terrorism studies be conducted by using the strongest feasible designs. In the following sections we describe how using the Internet can enhance the design of these studies, focusing on three specific design features: probability sampling, psychometrically sound assessment of outcomes and other postexposure factors, and use of longitudinal designs.

Probability Samples

All community epidemiologic studies of disasters should include adequately sized population-based probability samples of persons who represent the full range of exposure levels (e.g., from *very high* to *none*). Probability sampling is critical to these studies because it is the foundation of the study's external validity. That is, the fundamental scientific basis for external validity (i.e., generalizability of results; Shadish, Cook, & Campbell, 2002) flows from the principle that statistics based on samples are unbiased estimates (i.e., representative) of population parameters to the extent that every member of that population has a known and nonzero probability of being in the sample. The external validity of estimates based on study samples that are not probability samples of the population to which inference is intended is completely unknown, and the estimates from such studies typically can be generalized only to the people who participated in them. Stated in a different way, samples are not representative of a given population because of who is in them, but rather because of who could have been in them.

But how can probability samples be drawn of large populations (e.g., the Los Angeles metropolitan area, the United States), given that making a list of all members of the population and then drawing the sample from the list is often literally not feasible? Modern probability samples of community populations are typically developed in one of two ways. Area probability sampling methods take advantage of the facts that (1) most people have a "home" (i.e., a place where they "live"), (2) homes are less transient than people, and (3) it is easier to identify, and make and maintain a list of, homes than of people. Survey samples for studies of the U.S. population, for example, are typically multistage, area probability samples. Briefly, at the first stage researchers draw a sample of specific geographic areas from the universe of all defined geographic areas in the United States; then they select samples of housing units within those areas; and finally they select people within the chosen housing units. In this way, every person living in the United States has a known and nonzero probability of being in the sample (ignoring for the moment the issue of homelessness).

The second main approach to probability sampling for community studies involves random digit dialing (RDD). RDD methods make use of another "most people have . . . " reality: Most residential dwellings in the United States (about 94%, on the basis of recent census estimates) have

a land-line telephone. RDD focuses on land-line phones because (1) they are literally "tied" to a dwelling and (2) federal law prohibits targeting cellular phone numbers in RDD (and in telemarketing, etc.) because cellular phone customers are charged for calls made to their cell phones, whereas land-line phone customers are not (i.e., cell phone customers pay when you call them). Briefly, in RDD surveys the telephone exchanges (first three digits of telephone numbers) that serve the specific area in which the population of interest lives (e.g., city of Chicago, entire United States) are identified and a sample of exchanges is drawn; then samples of numbers within each exchange are drawn, and those samples represent the pool from which specific numbers are randomly chosen and dialed. When someone answers the phone, the interviewer first conducts a brief screening interview to establish that the phone is in a residence rather than a business, then determines how many people live at the residence, and then attempts to recruit the person who answered the phone or another household member into the study.

Unfortunately, much of the Internet-based research to date has been conducted with volunteer rather than probability samples. As the Internet has become more popular, many have sought to use it because of the relative ease of obtaining large samples. Thus, Internet "instant polls" have become ubiquitous (e.g., on Web sites such as www.cnn.com). Harris Interactive maintains a "research" panel with "multimillion participants" recruited primarily via their Web site (www.harrisinteractive.com) who have "expressed interest in participating in clinical trials and/or market research studies." As a result, the panel can provide relatively large numbers of people who have specific characteristics for market research or other studies. Although the panel includes many people and therefore samples drawn from it can be quite large, even estimates based on random samples drawn from it are valid only for the full panel of volunteers, not for the U.S. general (or any other) population.

In addition, a large number of commercial software systems for managing online data collection have become available in recent years. These systems are designed to facilitate rapid and relatively inexpensive hosting of a survey. As a result, announcements about Web-based surveys are now commonly broadcast on listservs or through e-mails or other recruitment materials that provide links to an online questionnaire. Although the numbers of respondents to such efforts can be very large, these samples of convenience are also not probability-based, and therefore the generalizability of findings from such studies is very limited and the selection biases unknown.

These facts point to an important truth about using the Internet for epidemiologic studies today: Although the Internet can offer tremendous advantages as a data collection medium, it is rarely useful as a vehicle for drawing samples for such studies. Census figures indicate that although Internet use in the United States has been growing over the years, only about 60% of the U.S. population over age 18 had use of a computer at home, school, or work by September 2001 (U.S. Census Bureau, 2001). Thus, those individuals who have easy access to the Internet cannot be considered to be "representative" of the U.S. population.

The primary exception to concerns about using the Internet to draw a study sample involves circumstances in which a list of a population of interest is available and includes a current e-mail address for each person on the list. Examples of such exceptions are typically limited to establishment surveys, such as a large corporation that wants to assess job satisfaction among its employees without the burden and expense of surveying every employee, or a university that is seeking information about student attitudes related to an important policy topic.

Psychometrically Sound Assessment of Outcomes and Other Postexposure Factors

Although the specific outcomes that are assessed depend primarily on the study's aims, disaster and terrorism studies typically include a comprehensive assessment of PTSD, depression, and selected other health and psychosocial outcomes. Additionally, measures of postexposure health and mental health service use, social support, and new trauma exposures have often been included in such studies. More recently, interest in also including contextual measures

(e.g., community or neighborhood characteristics, social network characteristics) has been increasing, caused, in part, by the availability of statistical software (e.g., HLM; Raudenbush & Bryk, 2002) that models multilevel data appropriately.

For pragmatic reasons, most or all of these assessments are necessarily made via survey-based (i.e., screening) measures. To ensure the internal validity of study comparisons, however, all such measures must have been well validated against comprehensive clinical assessment in community (i.e., not treatment-seeking) samples.

A growing literature has documented that sensitive topics, such as psychiatric symptoms, substance use, and details of sexual behavior, are more likely to be acknowledged in self-report assessments than in interview-based assessments. Findings from randomized experiments document that when research participants respond to questions without interacting directly with an interviewer, they are more likely to reveal sensitive and/or personal information (Lau, Thomas, & Liu, 2000; Turner, Lessler, & Gfroerer, 1992; Turner et al., 1998). More specifically, research comparing interview modalities demonstrates that Web-based data collection improves the accuracy of reports that respondents provide over less anonymous interview modalities, particularly telephone interviews (Chang & Krosnick, 2001; Krantz & Dalal, 2000; Reips, 2000). This result is especially true when the reports in question are sensitive; in those cases Web-based data collection appears to reduce social desirability bias. To the extent that the admission of trauma-related symptoms, as well as distress, is uncomfortable in the presence of an interviewer, a Web-based methodology provides an excellent alternative. In fact, Web-based survey methodology offers enormous potential for improving the state of the art in survey research (Batinic, Reips, & Bosnjak, 2002; Couper, 2000).

Given that this new method can facilitate access to important and perhaps previously untapped information, it is possible that data collection via the Internet allows more "honest" reporting of symptoms after terrorism or a community disaster than has previously been available. This potential advantage for Internet-based assessment over telephone and in-person interview methods, however, raises potential participant safety concerns (e.g., that focusing on the details of these topics with an already-distressed participant may exacerbate distress) that must be addressed in the study protocol. These typically involve provision of round-the-clock access, via toll-free phone numbers or e-mail, to professional counselors who can assess the distress and intervene (directly and/or via referral) when appropriate. The underlying issues of participant safety in epidemiologic studies of trauma exposure have been described in more detail by Schlenger et al. (2004).

Longitudinal Design

When possible, disaster and terrorism studies should use longitudinal designs that include at least one preexposure assessment of key constructs (e.g., specific exposures, outcomes, potential moderators) and multiple postexposure assessments. Longitudinal designs provide for both within- and between-subjects quasi-experimental comparisons, which help overcome some of the inference limitations associated with both cross-sectional and post-only designs. Additionally, new methods for analyzing longitudinal data developed over the past few decades, including applications of the random ("mixed") effects approach (Laird & Ware, 1982) and the generalized estimating equations (GEEs) approach (Zeger & Liang, 1986), model more comprehensively the multiple sources of variance in repeated measures designs and are more tolerant of missing data than traditional methods (e.g., repeated measures analysis of variance). As a result, these approaches are more powerful and less subject to bias than the traditional approaches.

Using the Internet can also facilitate the implementation of longitudinal studies. Internet-based data collection is cost effective for longitudinal research because the marginal cost of additional rounds of assessment is small relative to that of telephone or face-to-face interview methods. Additionally, maintaining contact with a panel over the course of a long-term longitudinal study via e-mail offers many advantages over the traditional reminder postcards, newsletters, phone calls, etc. Also, participant

confidentiality can be maintained via the use of participant identification numbers that do not reveal participant identities but allow researchers to link specific survey responses over time.

HOW CAN WEB-BASED STUDIES MEET ALL THESE CRITERIA?

As noted earlier, although there are some clear advantages associated with Internet surveys for disaster or terrorism studies—including rapid response and relative ease of conducting longitudinal follow-up—selecting samples via the Internet remains problematic. The authors of this article, however, both have experience with a probability-based research panel created by Knowledge Networks Inc. that is "Web-enabled" (Schlenger et al., 2002; Silver et al., 2002). Knowledge Networks is a survey research firm specializing in Web-based surveys that uses multistage probability sampling methods to create survey samples, using RDD telephone sampling methods to recruit a large "standing" panel of potential research subjects. For specific studies, Knowledge Networks typically selects a simple or stratified random sample from the panel, so that representation of the U.S. population is maintained. Estimates from Knowledge Networks samples for other studies have closely tracked census-based distributions of sociodemographic characteristics such as age, gender, race, Hispanic ethnicity, employment status, income, education, and regional distribution.

To our knowledge, the Knowledge Networks panel is the only available method at this time for conducting Internet-based survey research with a nationally representative probability sample (Couper, 2000; Dennis & Krotki, 2001). As part of their agreement to participate in the panel, respondents are offered free Internet service and a WebTV appliance by Knowledge Networks as an incentive to participate, or other financial incentives if the household is already Web-enabled (about 60% of panel participants report already having access to the Internet at the time they are enrolled). In return, panel members participate in 10- to 15-minute Internet surveys three to four times a month. Empirical studies have documented that the panel does not respond significantly differently over time to surveys than more "naive" survey respondents (Dennis, 2001, 2003). Survey responses are confidential, with identifying information never revealed without respondent approval. When surveys are assigned to panel members, they receive notice in their Knowledge Networks–provided password-protected e-mail account that the survey is available for completion. Surveys are self-administered and accessible any time of day for a designated period (typically 3 weeks), and participants can complete a survey only once. Each survey includes written informed consent, including a reminder that participants are always free to refuse to answer a particular question or survey. Moreover, participants may leave the panel at any time, and receipt of the WebTV and Internet service is not contingent on completion of any particular survey.

When such a panel is created in advance of the disaster or terrorist event (essentially mimicking the formation of a postevent RDD sample, but with the advantage of providing preexposure measures of some critical variables), several challenges are addressed. First, these preexisting samples provide known sampling characteristics and can allow population estimates. Second, a great deal of information can be collected from the sample before a disaster or terrorist attack occurs, enabling these premeasures to be linked to postevent response. For example, Silver et al. (2006) were able to utilize mental and physical health information (ailments and health care utilization) and behaviors (degree of television exposure, religious attendance, voting patterns) that were collected before the 9/11 attacks as predictors of post-9/11 outcomes, avoiding retrospective (and often biased) reporting of this information.

Third, longitudinal data collection is possible because a pre-event relationship has been established with participants and the ongoing panel is monitored through a preestablished e-mail account. Thus, attrition that may occur in other surveys as a result of participants moving and/or changing telephone numbers is minimized. For example, Silver et al. (2006) were able to follow their national sample from 2 weeks through 3 years post attacks, collecting data approximately every 6 months and securing

participation rates averaging around 80% per wave across seven waves of data collection.

MECHANICS OF WEB-BASED DATA COLLECTION

Space does not permit a full explication of the nuts and bolts of survey design on the Web, but excellent resources are available elsewhere to address many specific aspects of Internet-based data collection (see, e.g., Dillman, 2000; Dillman & Bowker, 2001; Norman, 2005). Some features of Web-based data collection are worth noting here, however. Because there is no interviewer and thus no opportunity for clarification during data collection, questions used in Internet surveys must be clear, written at a basic reading level, and devoid of jargon. Instructions must be clear and detailed, explaining the specific kinds of questions to follow and providing clarification as to how individual items should be completed. The full range of response options must be available (*not applicable*, *refused*, etc.), and skip patterns out of irrelevant questions must be clearly specified in advance and programmed accordingly.

The visual aspect of the survey becomes extremely important with Web-based methods, relative to interviewer-administered surveys. It is important to keep in mind that the specific Web browser employed, hardware utilized, and screen size all impact the way the survey appears to the respondent. Thus, formatting must be flexible and adaptable to these various possibilities. Unlike in telephone or face-to-face interviews, the researcher must be particularly attentive to visual features, such as font size and color, background color, screen layout (e.g., the number of questions provided per screen page vs. use of one long screen), or the necessity for the respondent to scroll across the screen to see the entire question or response option at one time. Decisions must be made regarding a number of other formatting issues, such as whether to use pull-down menus, whether the response options are provided horizontally or vertically, as well as what number of items are visible on a screen at any one time. Investigators must also decide whether respondents will be allowed to skip a particular question, whether its completion will be requested more than once if it is not answered, or whether a response will be required before the next screen appears. Finally, because of the flexibility of the Web-based design, open-ended responses can supplement closed-ended questions, as long as respondents are able to enter their answers via the keyboard and adequate and flexible response fields are provided.

A LOOK TOWARD THE FUTURE

Internet-based surveys offer some strong advantages over other data collection modalities in the flexibility and anonymity they provide for respondents. Surveys can be completed in the privacy of a respondent's home, at a time that is convenient to the respondent. Question delivery can be standardized, eliminating the challenges of interviewer training and the biases inherent in interviewer questioning. Time-consuming and error-prone steps of data coding and data entry are eliminated, as respondents complete answers on their own and data files are clean and complete at the conclusion of the data collection effort.

Nonetheless, several potential pitfalls of Internet-based data collection must also be considered. These include respondents' concerns about being identified (which requires assurances that information contained in "cookies" will not be used to link individuals to their answers), the need to ensure a strategy by which respondents cannot complete a survey more than once, and the need to develop a strategy that maximizes the likelihood that the person who completed the survey was in fact the targeted respondent. Knowledge Networks addresses this problem by providing all panel members with password-protected e-mail accounts, to which they then mail specific surveys to the panel members selected to participate.

Additionally, anecdotal evidence suggests the possibility that the proportion of households that have a land-line phone may soon drop substantially, as people move to full dependence on cellular phones. If that happens, it will produce major changes in the way survey data are collected and create an important barrier to probability sampling in community studies. Finally, sometimes the very population whom one might want to target may suffer infrastructure

disruptions that make timely Web-based data collection impossible (e.g., Internet service goes down, electricity is shut off). For example, although the September 11 terrorist attacks created massive infrastructure damage at the World Trade Center site, their impact outside the immediate attack area was relatively limited. By contrast, the monumental infrastructure damage associated with Hurricane Katrina and the evacuation of unprecedented numbers of survivors reduce substantially the applicability of Web-based approaches to events of this magnitude.

In addition, although we maintain that the use of Web-enabled panels recruited via probability-based methods is preferable to non-probability-based sample recruitment over the Internet, potential limitations of this method must also be acknowledged. First, preexisting panels (Web-enabled or otherwise) are only useful when they include adequate numbers of participants in the directly affected area(s), a shortcoming that is likely to limit their ability to contribute to studies of disasters or terrorist attacks that are focused solely on rural areas. Second, because panel respondents are requested to complete repeated surveys as part of their "contract," it is important to consider the possibility that respondent overload influences response in a fashion that may be difficult to assess. At this early stage in the use of this data collection modality, we also have too little information about the impact of the "professional respondent" on population estimates in general, and about the potential for bias of (relatively) frequent participation in surveys among participant responses in subsequent surveys. In addition, it is important to recognize that the use of existing Web-enabled panels can be expensive (although not necessarily more expensive than face-to-face or telephone-based data collection methods), and in order to collect immediate response data, funding must be made available to potential researchers very quickly.

Despite these and other limitations, the critical nature of the topic and the need for research evidence to guide the design of interventions for terrorism and other community disasters have led to the recognition of the value of Internet-based surveys as innovative methods in trauma research. The continuing steady rise in the availability of Internet access in the United States makes it clear that Internet data collection will be an important part of research on these topics for the foreseeable future. Until the Internet penetration rate exceeds 90% of the population, however, it is likely that we will see a growth in the use of mixed modes of data capture, in which survey participants have the opportunity to choose from a variety of response modes (e.g., Internet, telephone, pencil and paper) the one that best suits their circumstances. Nonetheless, with thoughtful applications of theory, careful design and implementation, and appropriate caveats, it is likely that Web-based methods can be a useful tool, and perhaps the eventual method of choice, in the repertoire of trauma researchers for many years to come.

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