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Cluster Sampling with Referral to Improve the Efficiency of Estimating Unmet Needs among Pregnant and Postpartum Women after Disasters

Jennifer Horney, PhD, MPH, CPH[a,*], **Marianne E. Zotti, DrPH, MS, FAAN**[b], **Amy Williams, MPH**[c], and **Jason Hsia, PhD**[d]

[a]Department of Epidemiology, University of North Carolina Gillings School of Global Public Health, Chapel Hill, North Carolina

[b]Emergency Preparedness for Pregnant Women & Newborns, Centers for Disease Control and Prevention/National Center for Chronic Disease Prevention and Health Promotion/Division of Reproductive Health, Atlanta, Georgia

[c]Centers for Disease Control and Prevention/Office of Noncommunicable Diseases, Injury and Environmental Health/National Center for Chronic Disease Prevention and Health Promotion/ Division of Reproductive Health/Applied Sciences Branch, Atlanta, Georgia

[d]Centers for Disease Control and Prevention/Office of Noncommunicable Diseases, Injury and Environmental Health/National Center for Chronic Disease Prevention and Health Promotion/ National Center for Chronic Disease Prevention and Health Promotion/Office on Smoking and Health/Global Tobacco Control Branch, Atlanta, Georgia

Abstract

Introduction and Background—Women of reproductive age, in particular women who are pregnant or fewer than 6 months postpartum, are uniquely vulnerable to the effects of natural disasters, which may create stressors for caregivers, limit access to prenatal/postpartum care, or interrupt contraception. Traditional approaches (e.g., newborn records, community surveys) to survey women of reproductive age about unmet needs may not be practical after disasters. Finding pregnant or postpartum women is especially challenging because fewer than 5% of women of reproductive age are pregnant or postpartum at any time.

Methods—From 2009 to 2011, we conducted three pilots of a sampling strategy that aimed to increase the proportion of pregnant and postpartum women of reproductive age who were included in postdisaster reproductive health assessments in Johnston County, North Carolina, after tornadoes, Cobb/Douglas Counties, Georgia, after flooding, and Bertie County, North Carolina, after hurricane-related flooding.

Results—Using this method, the percentage of pregnant and postpartum women interviewed in each pilot increased from 0.06% to 21%, 8% to 19%, and 9% to 17%, respectively.

[*]Correspondence to: Jennifer Horney, PhD, MPH, CPH, Research Assistant Professor, Department of Epidemiology, University of North Carolina Gillings School of Global Public Health, Campus Box 8165, 400 Roberson, Chapel Hill, NC 27599. Phone: 919-843-5566. jen.horney@unc.edu (J. Horney).

Conclusion and Discussion—Two-stage cluster sampling with referral can be used to increase the proportion of pregnant and postpartum women included in a postdisaster assessment. This strategy may be a promising way to assess unmet needs of pregnant and postpartum women in disaster-affected communities.

Introduction

Disasters have the potential to negatively affect the health of all people, including groups at elevated risk such as women of reproductive age (15–44 years of age) and their infants. Experiencing a disaster can increase stress, limit access to prenatal or postpartum care, interrupt contraception, and increase exposure to hazardous environmental contaminants. These exposures can in turn increase the risk of adverse birth outcomes, such as low birth weight, preterm delivery, and infant mortality. However, research to date has reported mixed results on the exact effects of disasters on maternal and child health outcomes. Some studies have found an increase in low birth weight and preterm deliveries after disasters (Tong, Zotti & Hsia, 2011), whereas others found no consistent effect (Hamilton, 2009; Harville, Xiong & Buekens, 2009), and still other studies showed the effects varied depending on disaster exposure (Xiong et al., 2008; Engel., Berkowitz, Wolff, & Yehuda, 2005; Lipkind, Curry, Huynh, Thorpe, & Matte, 2010).

In addition to the lack of consistency among the data, there is also still very few data on the effects of disasters on women of reproductive age, including their medical needs. One reason for this lack of data is the inherent difficulty in locating women of reproductive age for research studies. A common strategy for assessing the needs of women of reproductive age is through the use of newborn records or community surveys, such as convenience samples at health fairs or newborn clinics. These methods, however, are not practical after disasters. Finding pregnant and postpartum women is especially challenging because fewer than 5% of women of reproductive age are pregnant or postpartum at any time (Mosher, Martinez, Chandra, Abma, & Willson, 2004). Furthermore, in a 2008 study, Jamieson et al. (2009) calculated that there were approximately 3 million pregnant women in the United States at that time, compared with a national population of just over 300 million, indicating that 1% of the population is pregnant at any given moment.

Most of the studies that examine the associations between natural disasters in the United States and birth outcomes have derived their samples from two sources, birth records or women attending prenatal clinics. Although birth records are a good source for this information, those data are not available until at least 2 to 3 years after the disaster occurs. Furthermore, using this method increases the risk of an ecological inference fallacy, because the health status of individuals is assumed to reflect the average health status of the population. Likewise, investigators are limited in exploring factors affecting outcomes to those on the birth certificate. As such, investigators cannot measure factors such as disaster exposure and stressors. In addition, in the event of a catastrophic disaster, women may evacuate and give birth outside of the affected counties. Thus, their outcomes may not be represented in a sample pulled from birth files (Hamilton, 2009, Harville et al., 2009). Likewise, drawing samples from prenatal clinics is far from ideal, because data are not

collected on women who have not been able to access prenatal care and records do not capture information on pregnancies that do not end in a live birth.

Community Assessment for Public Health Emergency Response (CASPER) is a set of tools and methods designed by the Centers for Disease Control and Prevention (CDC) to rapidly collect reliable and accurate population-based public health information (CDC, 2009). CASPER methods and tools can be used to quickly measure the health status and basic needs of a community affected by a disaster by providing objective information that public health officials can use to direct resources and assets (Zane et al., 2010). The methods were originally developed by the World Health Organization's Expanded Program on Immunization for assessing vaccine coverage and adapted for use in postdisaster rapid needs assessments by the CDC (Henderson & Sundaresan, 1982; Malilay, Flanders, & Brogan, 1996). CASPER methods consist of a two-stage cluster sampling strategy with probability proportionate to population. Typically, 30 clusters (census blocks or block groups) are sampled in the first stage, and 7 subjects per cluster are randomly selected in the second stage (30 × 7), although other sample sizes may be used (e.g., 20 × 10 or 40 × 5) depending on the number of clusters and subjects in the sampling frame.

Community-based surveys have long been viewed as an important way to collect public health data from residents (Frerichs & Shaheen, 2001).Two-stage cluster surveys such as CASPER may be preferable to one stage, simple random samples because they do not require an enumeration of all the eligible persons in the population before selection. They also require relatively little formal epidemiologic or statistical training and may be done with the staff and funds available to local health departments (Frerichs & Shaheen, 2001). CASPERs have regularly been used by local health departments to assess vaccination coverage, particularly among hard-to-reach populations (Ewert, Thomas, Chun, Enguidanos, & Waterman, 1991; Goodman, Wu & Frerichs, 2000; Shaheen, Frerichs, Alexopolous, & Rainey, 2000), and to assess disaster-related needs (Berg et al., 2008).

From 2009 to 2011, we piloted an adaptation of the CASPER sampling strategy that sampled only women of reproductive age and included referrals to increase the proportion of pregnant and postpartum women who are included in postdisaster assessments. Each respondent selected via the two-stage cluster sampling strategy was asked to refer the interviewers to any pregnant or postpartum women they were aware of in the nearby area. Pilots were conducted in Johnston County, North Carolina, after tornadoes (November, 2008), Cobb/Douglas Counties in Georgia after flooding (September, 2009), and Bertie County, North Carolina, after hurricane-related flooding (October, 2010). Each pilot was conducted approximately 3 months after the disaster, to ensure that the data collection process did not interfere with recovery efforts.

Methods

Study Population and Sampling

To overcome the difficulty of identifying a sufficiently large sample of pregnant and postpartum women, a modified two-stage cluster sample with response rule was used. Using the typical two-stage cluster sample, in the first stage census blocks are selected probability

proportionate to the population and in the second stage random points or interview locations are selected using a site selection toolkit developed by the North Carolina Division of Public Health in ESRI ArcMap (Redlands, CA). Under the modified two-stage cluster sample, sampled households are asked as part of the interview to refer all pregnant or postpartum women they know within their cluster who are then contacted by the interview team. Women reached through referral were asked to participate in the survey and give informed oral consent under the same procedures as other potential participants. Therefore, for referred pregnant and postpartum women, we apply a single stage cluster sample that is produced from the two-stage cluster sample with referral.

In the Johnston County, North Carolina, pilot, households were selected for inclusion in the pilot survey based on a two-stage cluster survey sampling methodology modified with a response rule. In the first stage, 10 census blocks were selected probability proportionate to population from all census blocks within a one mile radius of the tornado's touchdown in Johnston County, North Carolina; in the second stage, seven random points were generated in each selected census block using a site selection tool in ESRI ArcMap resulting in a 10 × 7 sampling frame. To overcome the difficulty of identifying a sufficient sample of pregnant and postpartum women in the community, selected households were asked to refer the interview team to any pregnant or postpartum women they knew within their cluster.

Georgia's pilot households were selected for inclusion in the pilot survey using the two-stage cluster survey sampling methodology that was modified with a response rule. In the first stage, census block groups were selected probability proportionate to population from all census block groups in the two counties where flood-related deaths had been confirmed or where household damage had been reported through windshield surveys conducted by local officials; in the second stage, seven random points were generated in each selected census block group using a site selection tool in ESRI ArcMap resulting in a 30 × 7 sampling frame. All selected households were again asked to refer the interview team to any pregnant or postpartum women they knew within their neighborhood.

In the Bertie County, North Carolina, assessment, maps of the county were obtained from the United States census. To ensure that the most severely flooded area of the county near the town of Windsor was included in the selected census blocks, all blocks in the county were first stratified by those that had an intersection with the town of Windsor municipal boundaries and those that did not. To ensure that there were eligible women in each selected block, Census data was also used to determine the median age of women living in the block and only blocks where the median age was 45 years of age or younger were eligible for selection. Twenty census blocks in each stratum with a median age for women of 45 years of age or younger were then randomly selected based on probability proportionate to population size. Because populations in each block were small, five interview locations were chosen within each selected block from a simple random sample of all existing parcels using a geographic information systems-based survey site selection toolkit developed by the North Carolina Division of Public Health in ESRI ArcMap 9.2, resulting in a 40 × 5 sampling frame.

For all three pilots, data were collected using global positioning systems-equipped Magellan Mapper field data collectors via in-person interviews with one woman aged 18 to 44 in each selected household. Data were recorded on an electronic form at the time of interview. Interviewers were routed to each location with a paper map generated with ESRI ArcPad 6.0.3 Street Map USA, and all selected survey sites were also loaded in Garmin Nuvi car GPS units. Selected households were approached by an interview team, and eligible respondents, including referred women, gave oral informed consent. This research received approval by the Institutional Review Board of the University of North Carolina at Chapel Hill Gillings School of Global Public Health (Public Health IRB #09-0077).

Questionnaire

A quantitative survey instrument was developed by the Division of Reproductive Health at the CDC and the University of North Carolina at Chapel Hill. The questionnaire included questions from the Pregnancy Risk Assessment Monitoring System, the Behavioral Risk Factor Surveillance System, the Reproductive Health Assessment Toolkit for Conflict Affected Women, and Florida Healthy Start, in addition to several unique questions. The questionnaires were edited after each pilot test, primarily to shorten the time required to conduct an interview.

The questionnaire included seven sections. The first section contained questions on background characteristics, including age, race, ethnicity, educational attainment, income, and marital status, as well as the extent of damage the participant faced from the disaster and type of health insurance. The second section was only for pregnant women and included questions on gestational age, initiation of prenatal care, barriers to prenatal care, the effect of the disaster on prenatal care, and underlying chronic health conditions. The third section was only completed by postpartum women and focused on postpartum care for the mother, the baby's size and gestational age at birth, medical care since birth, and infant feeding practices, including difficulties pertaining to feeding because of the disaster. The fourth section included questions on family planning and was completed by all nonpregnant women. The questions assess the woman's utilization of family planning methods before and after the disaster, as well as where the woman obtains her method, and barriers to use. The fifth section focused on family stressors, risk behaviors, and needs, and was completed by all participants. Questions centered on exposure to various adverse experiences during the disaster (such as walking through floodwater or losing a job), care giving responsibilities before and after the disaster, food intake before and after the disaster, feeling unsafe before and after the disaster, substance use, sexual practices, services needed, and preferred source of disaster-related information. The sixth section asked questions about violence, and was completed by all participants. The final section was a repeat of four previously asked questions to determine survey reliability. This section was also completed by all eligible participants, who were women age 18 to 44.

Data Analysis

Data were downloaded from Magellan Mapper® handheld computers and imported into Excel (2007, Redmond, WA) and SAS (9.1.2, Cary, NC) for calculation of frequencies.

Results

In the three pilots, 2,813 houses were approached. Of the 411 homes that had an eligible woman at home, 236 interviews were conducted, including 43 with women who were either pregnant or fewer than 6 months postpartum.

Johnston County, North Carolina

Twenty people in 10 survey teams approached a total of 105 households during the one-half day pilot conducted on a March, 2009, weekday afternoon between 12:00 PM and 5:00 PM. Fifty-two percent (55 of 105) of households had someone at home and 44% (24 of 55) of those had an eligible woman of reproductive age at home. Of these 24, 16 interviews (one interview with a pregnant or postpartum woman) were conducted for a response rate of 66%. In addition, 31% (17 of 55) of households gave interview teams referrals for pregnant and postpartum women they knew within or near their cluster and three additional pregnant and postpartum women were interviewed based on these referrals, bringing the total number of women interviewed to 19, with four pregnant or postpartum. The use of referrals increased the proportion of the sample that was pregnant or postpartum from 0.06% (1 of 16) to 21% (4 of 19; Table 1).

Cobb and Douglas Counties, Georgia

Nine survey teams totaling 18 people approached a total of 1,071 households in the two counties over the 3-day period in October, 2009 (Thursday October 29, 2009, from 10 AM to 6 PM; Friday October 30, 2009, from 10 AM to 6 PM; and Saturday October 31, 2009, from 9:30 AM to 2 PM). Thirty-nine percent (421 of 1,071) of households in Cobb/Douglas had someone at home and 44% (185 of 421) had an eligible woman of reproductive age at home. Of these 185, 64 interviews (five interviews with a pregnant or postpartum woman) were conducted for a response rate of 35%. The rate was lower than the in other pilots, which may have been in part because of the more urban setting and the timing of the survey very near election day 2010, making respondents less likely to agree to respond to a survey. In addition, 12% (49 of 421) of households gave interview teams referrals for nearby pregnant and postpartum women and nine additional pregnant and postpartum women were interviewed based on these referrals, bringing the total number of women interviewed to 73, with 14 pregnant or postpartum The use of referrals increased the proportion of the sample that was pregnant or postpartum from 8% (5 of 64) to 19% (14 of 73).

Bertie County, North Carolina

A total of 1,637 homes were approached by 14 people in seven teams over 7 days in March, 2011. Forty-five percent (731 of 1,637) of households had someone at home and 28% (202 of 731) of those has an eligible woman of reproductive age at home. Of these 202, 131 interviews (12 interviews with a pregnant or postpartum woman) were conducted for a response rate of 65%. Fifty-seven eligible women refused to be interviewed, and one interview could not be conducted because of a language barrier between the interview team and the eligible woman. In addition, 7% (48 of 731) of households gave interview teams referrals for nearby pregnant and postpartum women and 13 additional pregnant and postpartum women were interview based on these referrals bringing the total number of

women interviewed to 144, with 25 (17%) pregnant or postpartum. The use of referrals increased the proportion of the sample that was pregnant or postpartum from 9% (12 of 131) to 17% (25 of 144).

Discussion

This percentage of pregnant and postpartum women identified and interviewed as part of these pilots is significantly higher than the estimated 5% of the population of women of reproductive age (15–44 years of age) that meets those conditions at any given time, indicating that the modified CASPER method is effective at locating pregnant and postpartum women to learn about their unmet needs after disasters (Jamieson et al., 2009). Using this method, the percentage of pregnant and postpartum women interviewed in each pilot increased from 0.06% to 21% in Johnston County, from 8% to 19% in Cobb and Douglas Counties, and 9% to 17% in Bertie County.

A traditional CASPER is designed to provide relatively rapid and low-cost population-based estimates of unmet needs in the postdisaster setting in order to inform decision makers and set priorities for action. Typically, 10 two-person interview teams can complete the 210 interviews for a CASPER in 24 to 72 hours. In this modified CASPER, additional time and effort are required to identify eligible women of reproductive age and follow up on referrals to pregnant and postpartum women. However, some strategies can be employed to improve efficiency. Interviews can be conducted in early evenings and on weekends, which is likely to increase contact rates and response rates. In addition, before clusters are selected for inclusion, Census data can be used to exclude blocks where there are no households or where the median age is over 45. Areas zoned as business or industrial can also be excluded at the second stage, ensuring that there are homes located near the random points generated as interview locations. These modifications should be undertaken with caution, however, to ensure that sparsely populated but highly impacted areas are not left out of the sample.

This modified CASPER is best implemented after a fairly widespread disaster, such as a hurricane or extensive flooding. Because state or federal disaster declarations are typically made on the county level, the extent of damage may vary widely by location. In the initial pilot, conducted in response to a tornado, the disaster affected area was small, and few households that participated in the survey suffered damage or were affected by the disaster. Changes were made to the sampling strategy in the second and third pilots to address this concern. In Cobb, Douglas, and Bertie Counties, damage assessments conducted by emergency management and other public officials were utilized to ensure that the census blocks eligible for inclusion in the study included areas where confirmed damage, injuries, or deaths had occurred, increasing the probability that a respondent would have experienced some disaster impact such as property damage or stressors. Additionally, in response to larger or longer term disasters, multiple assessments could be conducted in different areas affected by a disaster and longitudinal assessments could be used to measure change over time.

The use of the referral method was successful in reaching more pregnant and postpartum women, but it does add complications to data analysis and interpretation. Referrals are a

single-stage sample embedded in a two-stage sample and weights must be appropriately applied to obtain valid results. For analysis of reproductive age women, sample weights would need to be developed based on two-stage cluster sampling, where in the first stage the sample weight would be the inverse selection probability of primary sampling units and in the second stage the sample weight would be the inverse selection probability of a household chosen from the previously selected primary sampling units. The sample weight for selected reproductive age women would then be a product of the two weights multiplying the number of eligible reproductive age women in the selected household.

As mentioned, it is difficult to identify a sufficient number or pregnant or postpartum respondents using traditional sampling methods. Asking neighbors for referrals to pregnant or postpartum women in the community raises issues of confidentiality and anonymity. This issue is complex, particularly because it involves personal issues such as pregnancy. The two-stage sample with referral is parallel in some respects to the more traditional snowball sampling, a method in which households initially selected are used as informants to locate other households with certain characteristics that make them eligible for the sample (Penrod, Preston, Cain, & Starks, 2003). However, snowball sampling is only recommended among respondents who are members of a special population and are familiar with others in that population. In this instance, we ask all households to provide referrals to nearby pregnant or postpartum women, opening up the possibility that women who are not pregnant or postpartum may refer the interview team to those who are. During the three pilots, there was only one instance of a household with more than one eligible woman of reproductive age at home. If this circumstance is encountered, the interview team should randomly select one woman for interview. In this case, the selected reproductive age woman would represent two times the inverse probability of selecting this household times the inverse probability of selecting this primary sampling units.

These pilot studies have several limitations. In the first two pilots, sample sizes were small and the total number of completed interviews was significantly less that the targeted 200 or 210 of a typical CASPER. Additionally, not every household with an eligible woman of reproductive age had experienced the effects of the disaster. Sampling in the second and third pilots was altered to ensure that there was documented damage in the sampled areas, that areas zoned nonresidential were eliminated, and that the median age of the included blocks was 45 years of age or younger. Even with these refinements to the sampling frame, only 28% (40 of 144) of those who completed the survey in Bertie County reported flood-related home damage. If women who were at highest risk of experiencing unmet needs after a disaster were also most likely to be missed in the survey, there is the potential for response bias. For example, renters, those living in poverty, or other underserved groups may have been more likely to relocate after the disaster or to stay with friends or family in other unaffected areas. This was partly addressed by partnering closely with the local health departments in each pilot location and publicizing pilots in the community in an effort to increase trust and improve response rates. Finally, asking for referral also may introduce response bias if pregnant and postpartum women with larger social networks are more likely to be referred.

Conclusion

The modified CASPER methodology was effective at identifying women of reproductive age, including pregnant and postpartum women, in the community after a disaster. However, the results from these three pilots highlight some of the challenges of this approach, including the large investment of time and resources currently necessary to carry out postdisaster assessments of a target population and the difficulty in finding disaster-affected residents, even in a community affected by a widespread disaster. This approach may also be problematic to implement after a disaster that resulted in mass displacement of residents outside of the disaster-impacted area. However, given the seriousness of the many potential adverse outcomes on the health of women and infants after disasters, it is critical to continue to refine methods that can improve our understanding of their disaster experience.

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Biographies

Jennifer Horney, PhD, MPH, CPH, is a Research Assistant Professor in the Department of Epidemiology at the University of North Carolina Gillings School of Global Public Health. Her research interests include risk assessment and decision making during disasters.

Marianne E. Zotti, DrPH, MS, FAAN, is Lead Epidemiologist, Emergency Preparedness for Pregnant Women & Newborns at the Centers for Disease Control and Prevention. Her research interests are in the health effects of disasters on preconception health, prenatal health and pregnancy outcomes.

Amy Williams, MPH, is an ORISE Fellow at the Centers for Disease Control and Prevention. Her research interests are maternal and child health, particularly birth outcomes.

Jason Hsia, PhD, is a Mathematical Statistician at the Centers for Disease Control and Prevention. His research interests are statistical methods for population-based studies.

Table 1

Efficiency of Referral for Identifying Pregnant and Postpartum Women in Three Pilot Studies

	Johnston County, NC, n (%)	Cobb/Douglas Counties, GA, n (%)	Bertie County, NC, n (%)
Contact rate	55/105 (52)	421/1071 (39)	731/1637 (45)
Contact rate – eligible woman of reproductive age	24/55 (44)	185/421 (44)	202/731 (28)
Referral rate	17/55 (31)	49/421 (12)	48/731 (7)
Response rate	16/24 (66)	64/185 (35)	131/202 (65)
Pregnant and postpartum women reached without referral	1/16 (6)	5/64 (8)	12/131 (9)
Pregnant and postpartum women reached with referral	4/19 (21)	14/73 (19)	25/144 (17)