PUBLIC HEALTH REPORTS

Public Health Reports
1–9

DOI: 10.1177/00333549221142571
journals.sagepub.com/home/phr
SAGE

Pregnant Women's Experiences During and After Hurricanes Irma and Maria, Pregnancy Risk Assessment Monitoring System, Puerto Rico, 2018

Regina M. Simeone, PhD[1]; L. Duane House, PhD[1]; Beatriz Salvesen von Essen, MPH[1,2]; Katherine Kortsmit, PhD[1]; Wanda Hernandez Virella, MPH[3]; Manuel I. Vargas Bernal, MD[3]; Romeo R. Galang, MD[1]; Denise V. D'Angelo, MPH[1]; Carrie K. Shapiro-Mendoza, PhD[1]; and Sascha R. Ellington, PhD[1]

Abstract

Objective: Exposure to natural disasters during and after pregnancy may increase adverse mental health outcomes. Hurricanes Irma and Maria struck Puerto Rico in September 2017. Our objectives were to understand hurricane-related experiences, maternal health concerns, and the impact of hurricane experiences on postpartum depressive symptoms (PDS).

Methods: We used data from the 2018 Pregnancy Risk Assessment Monitoring System to describe differences in maternal hurricane experiences among women who were pregnant during and after the 2017 hurricanes. We assessed maternal concerns and PDS. We estimated adjusted prevalence ratios (aPRs) and 95% CIs for the associations between hurricane experiences and PDS.

Results: The most frequently reported hurricane experiences were losing power for ≥1 week (97%) and feeling unsafe due to lack of order/security (70%). Almost 30% of women who were pregnant during the hurricanes reported missing prenatal care. PDS were reported by 13% of women. Most hurricane experiences were associated with an increased prevalence of PDS. Feeling unsafe (aPR = 2.4; 95% CI, 1.2-4.9) and having difficulty getting food (aPR = 2.1; 95% CI, 1.1-4.1) had the strongest associations.

Conclusions: Most women who were pregnant during or after hurricanes Irma and Maria struck Puerto Rico reported negative hurricane experiences, and most experiences were associated with an increased prevalence of PDS. Understanding the experiences of pregnant women during and after disasters and identifying risks for adverse mental health outcomes after pregnancy are important to inform emergency preparedness and prenatal and postpartum care.

Keywords

hurricanes, maternal health, pregnancy, prenatal, preparedness, disaster, PRAMS

In September 2017, two hurricanes struck Puerto Rico in quick succession. On September 6, 2017, the eye of Hurricane Irma, a category 5 storm, passed close to Puerto Rico.[1,2] Shortly thereafter, on September 20, 2017, Hurricane Maria, a category 4 storm, made landfall on Puerto Rico.[1,2] The storms inflicted substantial damage—almost the entire island lost electricity and wireless communication for an extended period; households lacked potable water; and homes and other infrastructure across the island sustained major structural damage.[1,3-5] Additionally, medical infrastructure,

[1] Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA
[2] CDC Foundation, Atlanta, GA, USA
[3] Puerto Rico Department of Health, San Juan, Puerto Rico

Corresponding Author:
Regina M. Simeone, PhD, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Reproductive Health, 4770 Buford Hwy, MS S107-2, Atlanta, GA 30341, USA.
Email: rsimeone@cdc.gov

including hospitals, was damaged or nonoperational.[6] Recovery was slow: approximately 1 month after the hurricanes, 83% of Puerto Rico residents and businesses remained without electricity.[7-10] The type of hurricane exposures and the impact of these exposures on the health of pregnant women after hurricanes Irma and Maria are unknown.

The Pregnancy Risk Assessment Monitoring System (PRAMS) is an ongoing, cross-sectional, population-based surveillance system that assesses maternal behaviors and experiences before, during, and after pregnancy. PRAMS is conducted by the Centers for Disease Control and Prevention in collaboration with participating jurisdictions.[11] The PRAMS disaster supplement was implemented from June through December 2018 to understand the disaster-specific needs and concerns of pregnant women in the aftermath of hurricanes Irma and Maria. Our objectives were to (1) describe the prevalence of hurricane experiences and maternal health concerns overall and by pregnancy period during and after the hurricanes among women with a recent live birth in Puerto Rico and (2) examine the association between hurricane experiences and maternal postpartum depressive symptoms (PDS).

Methods

Data Collection

The methodology of PRAMS data collection has been described previously.[12] Briefly, women with a recent live birth are randomly sampled from birth certificate records and contacted to complete the survey by mail or telephone 2 to 6 months after birth.[13] The Puerto Rico PRAMS protocol received institutional review board review and approval from the Centers for Disease Control and Prevention and the University of Puerto Rico Medical Sciences Campus. The PRAMS questionnaire can be modified to collect information related to new and emerging issues affecting maternal and child health.[14] The full PRAMS survey was conducted throughout 2018 in Puerto Rico. A 10-question disaster supplement designed to assess experiences during and after hurricanes Irma and Maria was initiated June 12, 2018, and ended December 7, 2018 (eFigure 1 in Supplemental Material); only women with births occurring February through September 2018 were administered the disaster supplement (eFigure 2 in Supplemental Material).

Variables

Using month of infant birth and gestational age, we estimated the month of last menstrual period of all respondents. We categorized women with an estimated last menstrual period from April through September 2017 as pregnant during the hurricanes and women with an estimated last menstrual period from October 2017 through January 2018 as becoming pregnant during hurricane recovery (eFigure 2 in Supplemental Material). Because the disaster supplement was implemented for 6 months, women with births occurring before February 2018 or from October through December 2018 did not receive or respond to the supplement. Therefore, no women in the third trimester during hurricane landfall or recovery were included. The estimated gestational age of respondents ranged from 1 to 23 weeks during hurricane landfall and 4 to 20 weeks during hurricane recovery (eFigure 2 in Supplemental Material). The disaster supplement questions asked about experiences resulting from hurricanes Irma and Maria (eg, "I felt like my life was in danger when the disaster struck") and occurrence of major home damage (eg, "My home had major damage"). Similar exposure types were combined to capture disruptions in housing and challenges in obtaining food or disaster relief (eTable in Supplemental Material). Responses to these questions formed 15 categories of hurricane experiences (eTable in Supplemental Material).

Separate from the hurricane experiences, we investigated maternal concerns or experiences that occurred after the hurricanes but while the respondent was still pregnant (eg, "I worried about my baby's health") and whether women missed prenatal care appointments due to the hurricanes. We defined maternal self-report of PDS by responses of "always" or "often" from either of 2 questions: "Since your new baby was born, how often have you felt down, depressed, or hopeless?" and "Since your new baby was born, how often have you had little interest or little pleasure in doing things?"[15] We used the PRAMS questionnaire to obtain data on pregnancy intention and prenatal health insurance status, and we used birth certificate data for all other maternal and pregnancy characteristics.[12,16]

Analysis

We limited the analytic sample to women who responded to the disaster supplement. We assessed maternal characteristics by timing of pregnancy during the hurricanes (pregnant during hurricanes or pregnant during hurricane recovery). We calculated the prevalence of hurricane experiences, maternal concerns during pregnancy, and access to prenatal care by timing of pregnancy during the hurricanes. We calculated the prevalence of PDS among all women who responded to the disaster supplement, regardless of timing of pregnancy. We used the average marginal predictions approach to estimate adjusted prevalence ratios (aPRs) and 95% CIs to examine associations between hurricane experiences and report of maternal PDS. We limited the modeling analyses to hurricane experiences with at least 5 exposed and unexposed women reporting PDS. Models were adjusted for maternal age (≤19, 20-24, 25-34, ≥35 y), marital status (married, unmarried), education completed (<high school diploma or GED [General Educational Development], high school diploma or GED, some college or associate's degree, ≥bachelor's degree), prenatal health insurance (private, Medicaid, uninsured), and

pregnancy intention (unintended, intended, ambivalent). We also collected data on the following characteristics: receipt of Special Supplemental Nutrition Program for Women, Infants, and Children during pregnancy (yes or no); number of previous live births (0, 1, 2, or ≥3); number of prenatal care visits (≤8, 9-11, or ≥12); trimester of entry into prenatal care (first, second, or third/no prenatal care); and previous preterm birth (yes or no). PRAMS data are weighted for sampling design, nonresponse, and noncoverage to represent the live birth population of Puerto Rico. We conducted all analyses with SAS version 9.4 (SAS Institute Inc) and SAS-callable SUDAAN version 11.0 (RTI International) to account for sampling weights and complex survey design. To align with the American Statistical Association's statement on *P* values, we did not conduct formal significance testing.[17,18] Instead, we reported differences in prevalence >5% or an increased prevalence ratio of at least 50%.

Results

Overall, 517 women responded to the disaster supplement (Table 1); weighted, this total represented 54.8% of the full 2018 Puerto Rico PRAMS sample (n = 960). Of those who responded to the disaster supplement, 73.8% were pregnant when the hurricanes struck, and 26.2% became pregnant during hurricane recovery. Almost half (49.2%) of respondents were aged 25 to 34 years, 61.8% had Medicaid, and 58.3% had at least 12 prenatal care visits. These characteristics were similar by timing of the hurricanes in relation to pregnancy.

Nearly all women cited at least 1 adverse hurricane experience (99.3%); 97.1% indicated losing electricity for at least 1 week; and 71.0% reported feeling unsafe due to a lack of order or security after the hurricanes (Figure). Trouble getting food and clean water was common: 58.1% and 52.1% reported trouble getting food and clean water, respectively. Other common exposures were trouble getting services or disaster relief (38.9%), feeling that one's life was in danger (34.2%), housing disruption (36.9%), and walking through debris/floodwater (33.5%). While hurricane experiences were similar overall, women who became pregnant during the hurricane recovery had a slightly higher estimated prevalence of housing disruptions (43.1% vs 34.8%), walking through floodwater (42.5% vs 30.3%), and having a household member be injured or become ill (14.4% vs 10.1%), as compared with women who were pregnant during the hurricanes.

When compared with women who became pregnant during the hurricane recovery, a greater percentage of women who were pregnant when the hurricanes struck expressed concern about missing prenatal care (86.0% vs 73.2%), not being able to contact their doctor in case of an emergency (82.8% vs 70.8%), and their own health (84.8% vs 75.4%) (Table 2). Additionally, 27.1% of women who were pregnant when the hurricanes struck missed prenatal care appointments due to the hurricanes vs 4.8% of women who became pregnant during the hurricane recovery.

Overall, 13.7% of women reported PDS (Table 3). The prevalence of PDS was higher among women who were pregnant when the hurricanes struck than among women who became pregnant during the hurricane recovery (15.6% vs 8.3%) (Table 2). The prevalence of PDS was highest among women who became injured or ill (21.1%), lost personal belongings (20.7%), and were separated from loved ones (20.6%). After adjustment for confounding, women who felt unsafe due to a lack of order or security had a higher prevalence of PDS than women who did not (aPR = 2.4; 95% CI, 1.2-4.9). Similarly, women who had difficulty getting food, lost personal belongings, were injured or became ill, had trouble getting clean water, walked through debris or floodwater, and were separated from loved ones had a higher prevalence of PDS than women who did not report these experiences (aPR range, 1.7-2.1) (Table 3).

Discussion

Women who were pregnant when hurricanes Irma and Maria struck in Puerto Rico or became pregnant during hurricane recovery reported adverse hurricane experiences. Experiences included losing electricity, feeling unsafe due to a lack of order or security, and difficulty getting food and clean water. These experiences were similar regardless of timing of pregnancy. Women who experienced the hurricanes while pregnant had an increased prevalence of concerns about their own health, their ability to contact a doctor for emergencies, and missing prenatal care appointments when compared with women who became pregnant during the hurricane recovery. Prevalence of PDS varied by hurricane experience. Several experiences were associated with increased prevalence of PDS, including feeling unsafe, difficulty getting food or water, and losing personal belongings.

Studies of hurricane experiences and maternal mental health are limited. It is unclear if experiencing adverse hurricane events or having concerns during pregnancy might affect postpartum health, although some studies have observed associations with some outcomes. After Hurricane Katrina (New Orleans in 2005), women who were pregnant or became pregnant after the hurricane and who experienced substantial home damage, experienced injury to themselves or others, or perceived or experienced danger were at increased risk of depressive symptoms and symptoms of posttraumatic stress disorder.[19] Our analysis also observed a higher prevalence of PDS among women with certain hurricane experiences vs other experiences, suggesting that differences in disaster experience could differentially affect maternal postpartum mental health.

Pregnant and postpartum women and their infants are considered populations with special clinical and health care needs[20,21] and at risk of adverse health outcomes related to threats and disasters. The impact of disasters on access to food, mental distress, access to prenatal and obstetric health care, and access to postpartum health care can be

Table 1. Characteristics of women with recent live births responding to the Puerto Rico Pregnancy Risk Assessment Monitoring System hurricane supplement after hurricanes Irma and Maria, 2018[a]

Maternal characteristic	% (95% CI)		
	Total (N = 517)	Pregnant at hurricane landfall[b] (n = 365)	Became pregnant during hurricane recovery[c] (n = 152)
Total	—	73.8 (68.8-78.3)	26.2 (21.7-31.2)
Age group, y			
≤19	8.7 (6.2-12.2)	9.5 (6.5-13.9)	6.4 (2.9-13.3)
20-24	28.0 (23.4-33.0)	28.4 (23.1-34.3)	26.8 (18.6-37.0)
25-34	49.2 (43.8-54.6)	49.3 (43.0-55.6)	49.1 (38.7-59.5)
≥35	14.1 (10.7-18.4)	12.8 (9.1-17.8)	17.7 (10.9-27.5)
Education completed			
<High school diploma or GED	8.5 (6.0-11.9)	8.7 (5.8-12.9)	7.7 (3.8-15.1)
High school diploma or GED	24.8 (20.5-29.8)	21.2 (16.5-26.8)	35.0 (25.8-45.4)
Some college or associate's degree	31.5 (26.7-36.7)	33.9 (28.2-40.1)	24.5 (16.6-34.8)
≥Bachelor's degree	35.2 (30.2-40.7)	36.1 (30.2-42.5)	32.7 (23.6-43.4)
Marital status			
Married	35.2 (30.2-40.7)	34.3 (28.5-40.7)	37.8 (28.2-48.6)
Unmarried	64.8 (59.3-69.8)	65.7 (59.3-71.5)	62.2 (51.4-71.8)
Received Special Supplemental Nutrition Program for Women, Infants, and Children during pregnancy			
Yes	81.0 (76.0-85.1)	81.8 (76.0-86.5)	78.5 (67.9-86.4)
No	19.0 (14.9-24.0)	18.2 (13.5-24.0)	21.5 (13.6-32.1)
No. of previous live births			
0	47.8 (42.4-53.3)	50.1 (43.8-56.4)	41.3 (31.6-51.8)
1	34.3 (29.4-39.7)	33.5 (27.8-39.7)	36.8 (27.3-47.4)
2	13.6 (10.3-17.9)	14.2 (10.2-19.3)	12.0 (6.6-20.9)
≥3	4.2 (2.5-7.0)	2.2 (1.0-4.8)	9.9 (5.0-18.6)
Had prenatal health insurance[d]			
Private	38.2 (32.9-43.7)	39.4 (33.2-45.9)	34.6 (25.1-45.6)
Medicaid	61.8 (56.2-67.0)	60.5 (54.0-66.7)	65.4 (54.4-74.9)
Uninsured	0.1 (0.02-0.3)	0.1 (0-0.4)	0
Pregnancy intention[e]			
Unintended	46.4 (41.0-51.9)	47.8 (41.4-54.2)	42.5 (32.5-53.2)
Intended	43.1 (37.8-48.6)	41.1 (35.0-47.5)	48.8 (38.4-59.4)
Ambivalent	10.5 (7.6-14.4)	11.2 (7.7-15.9)	8.7 (4.4-16.3)
No. of prenatal care visits			
≤8	9.9 (7.4-13.2)	9.3 (6.5-13.2)	11.7 (7.0-18.7)
9-11	31.8 (27.0-37.0)	33.6 (27.9-39.8)	26.5 (18.4-36.6)
≥12	58.3 (52.9-63.5)	57.1 (50.8-63.2)	61.8 (51.5-71.2)
Trimester of entry into prenatal care			
First	85.4 (81.1-88.8)	86.8 (81.9-90.5)	81.4 (71.7-88.4)
Second	14.2 (10.8-18.4)	13.0 (9.3-18.0)	17.3 (10.6-26.9)
Third or no prenatal care	0.5 (0.1-2.0)	0.2 (0.1-0.4)	1.3 (0.2-8.3)
Previous preterm birth[f]			
Yes	3.8 (2.2-6.4)	2.5 (1.2-5.2)	7.4 (3.4-15.3)
No	96.2 (93.6-97.8)	97.5 (94.8-98.8)	92.6 (84.7-96.6)

Abbreviations: —, does not apply; GED, General Educational Development.
[a] Data source: Pregnancy Risk Assessment Monitoring System,[12] Puerto Rico 2018.
[b] Women with births occurring January–June 2018 were considered to be pregnant at hurricane landfall.
[c] Women with births occurring July–September 2018 were considered to have become pregnant during the hurricane recovery.
[d] 16 missing responses.
[e] 11 missing responses.
[f] 2 missing responses.

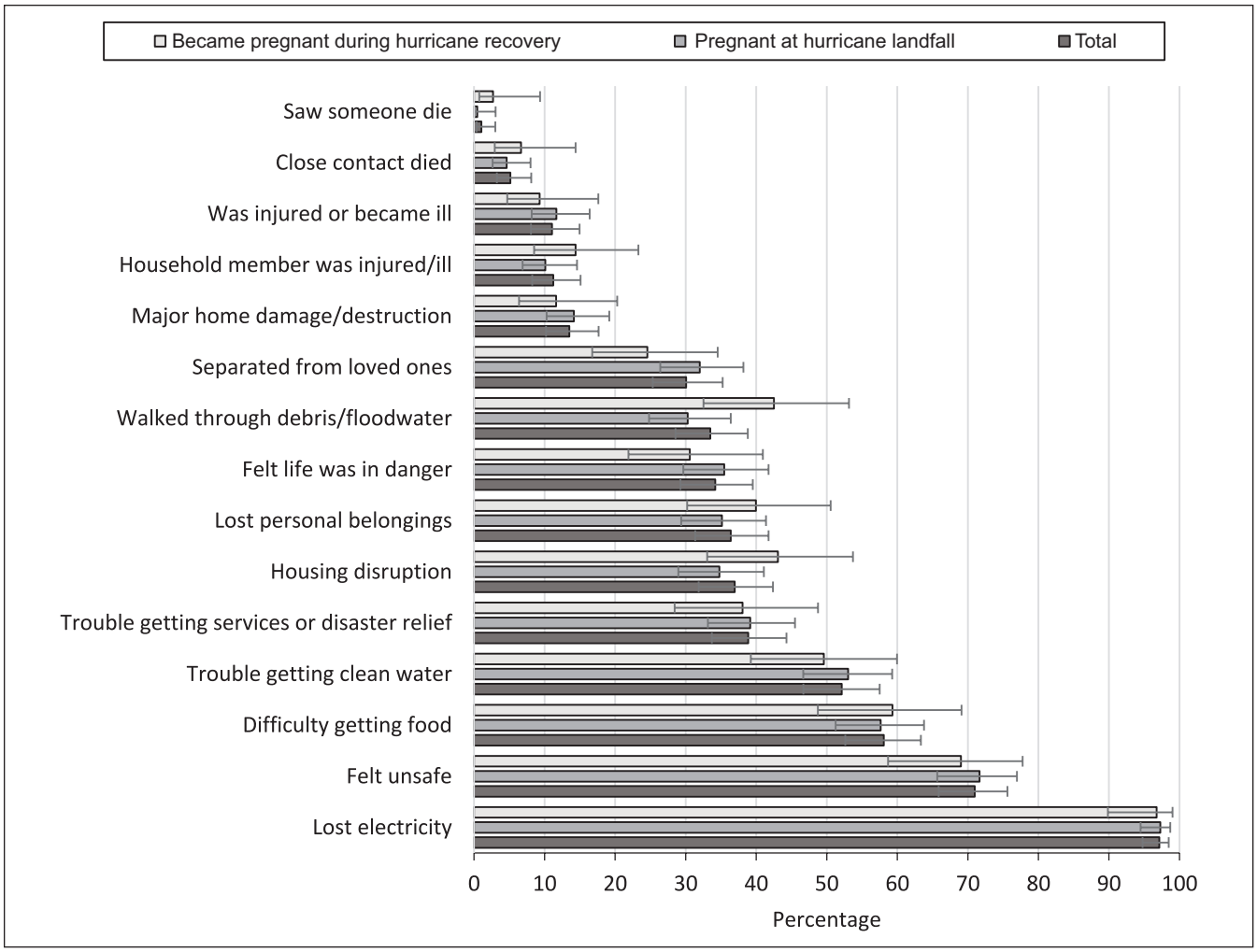

Figure. Distribution of hurricane experiences, stratified by timing of pregnancy during hurricanes, among women with recent live births responding to the 2018 Puerto Rico Pregnancy Risk Assessment Monitoring System hurricane supplement (N = 517). Women with births occurring during January–June 2018 were considered to be pregnant at hurricane landfall. Women with births occurring during July–September 2018 were considered to have become pregnant during the hurricane recovery. Error bars indicate 95% CIs. Data source: Pregnancy Risk Assessment Monitoring System,[12] Puerto Rico, 2018.

substantial.[22,23] Health sector and community preparation for disasters triggered by natural hazards can help reduce vulnerability to some adverse outcomes.[24,25] Preexisting telemedicine infrastructure that allows for virtual prenatal care and telephone triage may increase access to care for pregnant women and alleviate concerns about missing prenatal care appointments during disasters,[26,27] but for situations with prolonged recovery or in which communication mechanisms are unavailable, telemedicine may not be feasible. In our analysis, more than one-quarter of women who were pregnant during the hurricanes missed prenatal care appointments, and >85% reported being concerned about missing prenatal care appointments; however, most women had at least 12 prenatal visits. Establishing plans in consultation with their prenatal care provider for continued care before a disaster occurs may benefit pregnant women and alleviate maternal stress during pregnancy.

Mental health needs may be increased during and after disasters, requiring additional community, social, and health care considerations, especially for pregnant and recently pregnant women.[28,29] Screening for depression should occur during the prenatal and postpartum periods and be accompanied by evidence-based systems for diagnosis, counseling, treatment, and referral.[30-33] Furthermore, community supports for mental health services and ensuring that pregnant and recently pregnant women have adequate social connections may help protect maternal mental health.[29,34,35] Among 31 PRAMS sites in 2018, PDS were reported by 13.2% of women,[15] similar to the overall prevalence of PDS in the sample from Puerto Rico. However, our analysis suggests

Table 2. Maternal concerns and experiences due to hurricanes Irma and Maria by timing of pregnancy among women responding to the Puerto Rico Pregnancy Risk Assessment Monitoring System hurricane supplement (N = 517), Puerto Rico, 2018[a]

Maternal concern/event	% (95% CI)	
	Pregnant at hurricane landfall[b]	Became pregnant during hurricane recovery[c]
Worried about		
Baby's health	87.7 (82.9-91.4)	85.4 (76.4-91.4)
Missing prenatal care appointments	86.0 (81.0-89.9)	73.2 (62.8-81.5)
Being unable to contact doctor for an emergency	82.8 (77.4-87.2)	70.8 (60.2-79.5)
Own health	84.8 (79.6-88.9)	75.4 (65.2-83.4)
Getting an infection from others	61.6 (55.2-67.6)	69.1 (58.6-78.0)
Getting sick from drinking bad water	74.1 (68.1-79.3)	72.1 (61.7-80.6)
Getting sick from eating bad food	76.0 (70.1-81.1)	71.1 (60.6-79.8)
Getting an infection from mosquitos	93.0 (88.9-95.6)	88.8 (80.6-93.8)
Reported		
Missing prenatal care due to hurricane	27.1 (21.9-33.2)	4.8 (1.8-12.5)
Postpartum depressive symptoms	15.6 (11.5-20.9)	8.3 (4.1-16.3)

[a] Data source: Pregnancy Risk Assessment Monitoring System,[12] Puerto Rico, 2018.
[b] Women with births occurring January–June 2018 were considered to be pregnant at hurricane landfall.
[c] Women with births occurring July–September 2018 were considered to have become pregnant during the hurricane recovery.

Table 3. Prevalence of postpartum depressive symptoms and aPRs among women with hurricane experiences who had recent live births and responded to the Puerto Rico Pregnancy Risk Assessment Monitoring System hurricane supplement after hurricanes Irma and Maria (N = 517), 2018[a]

Maternal concern/event	No.[b]	Weighted % of PDS among women with each hurricane experience (95% CI)	aPR[c,d] (95% CI)
Respondents reporting PDS	67	13.7 (10.4-18.0)	—
Among women who reported			
Lost electricity[e]	65	13.8 (10.3-18.1)	—
Felt unsafe	53	16.1 (11.8-21.5)	2.4 (1.2-4.9)
Difficulty getting food	49	17.6 (12.8-23.8)	2.1 (1.1-4.1)
Trouble getting clean water	47	17.0 (12.0-23.4)	1.7 (0.9-3.1)
Trouble getting services or disaster relief	30	15.8 (10.3-23.3)	1.2 (0.7-2.2)
Housing disruption	25	15.5 (9.9-23.4)	1.3 (0.8-2.4)
Lost personal belongings	36	20.7 (14.3-29.1)	2.0 (1.1-3.6)
Felt life was in danger	28	17.7 (11.6-26.1)	1.4 (0.8-2.4)
Walked through debris/floodwater	31	18.9 (12.6-27.4)	1.7 (1.0-2.9)
Separated from loved ones	27	20.6 (13.6-29.8)	1.7 (1.0-2.9)
Major home damage/destruction	10	12.1 (5.3-25.3)	0.8 (0.3-1.8)
Household member was injured/ill	12	18.4 (8.8-34.3)	1.4 (0.7-3.0)
Was injured or became ill	13	21.1 (10.7-37.2)	1.9 (0.9-3.8)
Close contact died	2	7.2 (1.2-32.3)	—[e]
Saw someone die in disaster	0	0	—[e]

Abbreviations: aPR, adjusted prevalence ratio; PDS, postpartum depressive symptoms.
[a] Data source: Pregnancy Risk Assessment Monitoring System,[12] Puerto Rico, 2018.
[b] Among 517 women responding to the disaster supplement.
[c] Reference group for each hurricane experience was women who did not report that experience.
[d] Models adjusted for maternal marital status, maternal age, education, health insurance, and pregnancy intention.
[e] Models were not run for experiences with <5 exposed or 5 unexposed women.

that some hurricane experiences could increase the risk of this outcome. In such scenarios, increased community support and screening by health care professionals may be particularly important for women who experience stressors during or after natural disasters.

Health care providers can facilitate the care of their pregnant patients by encouraging individual- and family-level disaster preparedness.[36] Efforts to increase individual- and family-level emergency preparedness could be integrated into prenatal care to help reduce maternal, fetal, and infant risk for

adverse health outcomes during disasters.[36-39] Preparedness efforts for pregnant and recently pregnant women may include evacuation planning, having a home birthing kit, and infant care. While these efforts will be helpful immediately after a disaster, it is unlikely that any level of personal preparedness could have prepared pregnant women for the extended recovery required after hurricanes Irma and Maria.

Limitations

Our study had several potential limitations. First, because of the timing of the PRAMS disaster supplement, only women who were in their first or second trimester of pregnancy during the hurricanes or who became pregnant during the hurricane recovery were included. The experiences of women in their third trimester of pregnancy may have yielded different results, affecting the generalizability of these findings. Second, we grouped women in their first and second trimesters together, potentially obscuring differences. Third, the population of Puerto Rico changed substantially after hurricanes Irma and Maria,[40] and these population changes may have affected eligible women who were willing and able to participate in this survey. In an assessment of a separate birth cohort established in Puerto Rico, Watkins et al observed that after the 2017 hurricanes, women participating in the birth cohort who continued to reside in Puerto Rico had higher income and education levels than participants before the hurricanes.[41] Additionally, the birth rate in Puerto Rico decreased from 7.3 to 6.7 births per 1000 population from 2017 to 2018.[42,43] These population changes could have introduced selection bias and affected the generalizability of results. Furthermore, although their demographic characteristics were similar, it is possible that women who became pregnant during hurricane recovery, as compared with women who were already pregnant, had access to different resources, which potentially increased their resilience, or had different health characteristics.[44,45] It is therefore difficult to compare outcomes between these groups. Fourth, the damage from hurricanes Irma and Maria resulted in a more widespread impact and slower recovery than what is generally seen after hurricanes, which may also have affected the generalizability of results.[1,8] Finally, hurricane exposure data were collected via self-report, potentially contributing to recall bias, because women who were in different stages of pregnancy may recall experiences and concerns differently.

Conclusion

Hurricanes Irma and Maria in Puerto Rico broadly affected pregnant women, particularly in access to food, potable water, electricity, and feelings of safety. Women who were pregnant during the hurricanes or became pregnant during the hurricane recovery identified specific concerns about their health, the health of their pregnancy, and access to care in the aftermath. Additionally, women who felt unsafe, had difficulty accessing food and water, lost personal belongings, and were separated from loved ones had increased PDS as compared with women who did not have these experiences. Disasters are increasing in frequency.[46,47] It is important to collect data to understand the experiences and needs during the pregnant and postpartum periods in the context of disasters to inform appropriate screening and care.

Acknowledgments

The authors thank Idennys Magly Olmos, MS, and Beatriz Ríos Herrera, MPH, from the Puerto Rico PRAMS Team (Pregnancy Risk Assessment Monitoring System) and María M. Juiz Gallego, MPHE, CHES, from the Puerto Rico Demographic Registry for their work in conducting PRAMS surveillance. We also thank the PRAMS Team, Women's Health and Fertility Branch, Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, for its administration of the PRAMS surveillance system, including collection of the data.

Disclaimer

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Regina M. Simeone, PhD https://orcid.org/0000-0002-2779-3747

Katherine Kortsmit, PhD https://orcid.org/0000-0001-7972-9117

Supplemental Material

Supplemental material for this article is available online. The authors have provided these supplemental materials to give readers additional information about their work. These materials have not been edited or formatted by *Public Health Reports*'s scientific editors and, thus, may not conform to the guidelines of the *AMA Manual of Style*, 11th Edition.

References

1. RAND Corporation. Hurricanes Irma and Maria: impact and aftermath. Accessed March 17, 2022. https://www.rand.org/hsrd/hsoac/projects/puerto-rico-recovery/hurricanes-irma-and-maria.html
2. National Oceanic and Atmospheric Administration. Saffir-Simpson Hurricane Wind Scale. Accessed November 16, 2021. https://www.nhc.noaa.gov/aboutsshws.php

3. Federal Emergency Management Agency. Hurricanes Irma and Maria in Puerto Rico: mitigation assessment team report. FEMA P-2020. October 2018. Accessed March 21, 2022. https://www.fema.gov/sites/default/files/2020-07/mat-report_hurricane-irma-maria-puerto-rico_2.pdf
4. US Department of Housing and Urban Development. Housing damage assessment and recovery strategies report: Puerto Rico. June 29, 2018. Accessed October 18, 2021. http://spp-pr.org/wp-content/uploads/downloads/2018/07/HUD-Housing-Damage-Assessment-Recovery-Strategies-6-29-18.pdf
5. García-López GA. The multiple layers of environmental injustice in contexts of (un)natural disasters: the case of Puerto Rico post–Hurricane Maria. *Environ Just*. 2018;11(3):101-108. doi:10.1089/env.2017.0045
6. Zorrilla CD. The view from Puerto Rico—Hurricane Maria and its aftermath. *N Engl J Med*. 2018;377(19):1801-1803. doi:10.1056/NEJMp1713196
7. Fischbach JR, May LW, Whipkey K, et al. *After Hurricane Maria: Predisaster Conditions, Hurricane Damage, and Recovery Needs in Puerto Rico*. Rand Corporation; 2020. Accessed March 21, 2022. https://www.rand.org/pubs/research_reports/RR2595.html
8. Willison CE, Singer PM, Creary MS, Greer SL. Quantifying inequities in US federal response to hurricane disaster in Texas and Florida compared with Puerto Rico. *BMJ Glob Health*. 2019;4(1):e001191. doi:10.1136/bmjgh-2018-001191
9. Center for Puerto Rican Studies. Enduring disasters: Puerto Rico, three years after Hurricane Maria. 2020. Accessed March 11, 2022. https://centropr.hunter.cuny.edu/reports/enduring-disasters-puerto-rico-three-years-after-hurricane-maria
10. Pasch RJ, Penny AB, Berg R. National Hurricane Center tropical cyclone report: Hurricane Maria. February 14, 2019. Accessed March 11, 2022. https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf
11. Centers for Disease Control and Prevention. About PRAMS. Updated May 3, 2021. Accessed November 16, 2021. https://www.cdc.gov/prams/about/prams-faq.htm
12. Shulman HB, D'Angelo DV, Harrison L, Smith RA, Warner L. The Pregnancy Risk Assessment Monitoring System (PRAMS): overview of design and methodology. *Am J Public Health*. 2018;108(10):1305-1313. doi:10.2105/AJPH.2018.304563
13. Centers for Disease Control and Prevention. PRAMS: methodology. Updated May 4, 2021. Accessed November 16, 2021. https://www.cdc.gov/prams/methodology.htm
14. D'Angelo DV, Cernich A, Harrison L, et al. Disability and pregnancy: a cross-federal agency collaboration to collect population-based data about experiences around the time of pregnancy. *J Womens Health (Larchmt)*. 2020;29(3):291-296. doi:10.1089/jwh.2020.8309
15. Bauman BL, Ko JY, Cox S, et al. Vital signs: postpartum depressive symptoms and provider discussions about perinatal depression—United States, 2018. *MMWR Morb Mortal Wkly Rep*. 2020;69(19):575-581. doi:10.15585/mmwr.mm6919a2
16. Centers for Disease Control and Prevention. Are PRAMS data available to outside researchers? Page last reviewed April 26, 2022. Accessed December 27, 2021. https://www.cdc.gov/prams/prams-data/researchers.htm
17. Wasserstein RL, Lazar NA. The ASA statement on *P*-values: context, process, and purpose. *The American Statistician*. 2016;70(2):129-133. doi:10.1080/00031305.2016.1154108
18. Wasserstein RL, Schirm AL, Lazar NA. Moving to a world beyond "$P < 0.05$." *Am Stat*. 2019;73(suppl 1):1-19. doi:10.1080/00031305.2019.1583913
19. Harville EW, Xiong X, Pridjian G, Elkind-Hirsch K, Buekens P. Postpartum mental health after Hurricane Katrina: a cohort study. *BMC Pregnancy Childbirth*. 2009;9:21. doi:10.1186/1471-2393-9-21
20. Pandemic and All-Hazards Preparedness and Advancing Innovation Act of 2019, S 1379, 116th Cong (2019).
21. Pandemic and All-Hazards Preparedness Reauthorization Act of 2013, Pub L No. 113-5, 113th Cong (2013).
22. Buekens P, Xiong X, Harville E. Hurricanes and pregnancy. *Birth*. 2006;33(2):91-93. doi:10.1111/j.0730-7659.2006.00084.x
23. Callaghan WM, Rasmussen SA, Jamieson DJ, et al. Health concerns of women and infants in times of natural disasters: lessons learned from Hurricane Katrina. *Matern Child Health J*. 2007;11(4):307-311. doi:10.1007/s10995-007-0177-4
24. Ben Yahmed S, Koob P. Health sector approach to vulnerability reduction and emergency preparedness. *World Health Stat Q*. 1996;49(3-4):172-178.
25. World Health Organization. Risk reduction and emergency preparedness: WHO six-year strategy for the health sector and community capacity development. 2007. Accessed April 4, 2022. https://apps.who.int/iris/handle/10665/43736
26. American College of Obstetricians and Gynecologists. Committee opinion no. 726: hospital disaster preparedness for obstetricians and facilities providing maternity care. *Obstet Gynecol*. 2017;130(6):e291-e297. doi:10.1097/AOG.0000000000002413
27. Centers for Disease Control and Prevention. Disaster safety for expecting and new parents. Page last reviewed August 26, 2022. Accessed October 18, 2021. https://www.cdc.gov/reproductivehealth/features/disaster-planning-parents/index.html
28. Harville EW, Xiong X, Buekens P. Disasters and perinatal health: a systematic review. *Obstet Gynecol Surv*. 2010;65(11):713-728. doi:10.1097/OGX.0b013e31820eddbe
29. Giarratano GP, Barcelona V, Savage J, Harville E. Mental health and worries of pregnant women living through disaster recovery. *Health Care Women Int*. 2019;40(3):259-277. doi:10.1080/07399332.2018.1535600
30. Siu AL, US Preventive Services Task Force, Bibbins-Domingo K, et al. Screening for depression in adults: US Preventive Services Task Force recommendation statement. *JAMA*. 2016;315(4):380-387. doi:10.1001/jama.2015.18392
31. US Preventive Services Task Force; Curry SJ, Krist AH, Owens DK, et al. Interventions to prevent perinatal depression: US Preventive Services Task Force recommendation statement. *JAMA*. 2019;321(6):580-587. doi:10.1001/jama.2019.0007
32. ACOG Committee opinion no. 757: screening for perinatal depression. *Obstet Gynecol*. 2018;132(5):e208-e212. doi:10.1097/AOG.0000000000002927
33. Rafferty J, Mattson G, Earls MF, Yogman MW; Committee on Psychosocial Aspects of Child and Family Health. Incorporating recognition and management of perinatal depression into pediatric practice. *Pediatrics*. 2019;143(1):e20183260. doi:10.1542/peds.2018-3260
34. Bryant RA, Gallagher HC, Gibbs L, et al. Mental health and social networks after disaster. *Am J Psychiatry*. 2017;174(3):277-285. doi:10.1176/appi.ajp.2016.15111403

35. McFarlane AC, Williams R. Mental health services required after disasters: learning from the lasting effects of disasters. *Depress Res Treat*. 2012;2012:970194. doi:10.1155/2012/970194
36. Haeri S, Marcozzi D. Emergency preparedness in obstetrics. *Obstet Gynecol*. 2015;125(4):959-970. doi:10.1097/AOG.0000000000000750
37. Giarratano G, Sterling YM, Orlando S, et al. Targeting prenatal emergency preparedness through childbirth education. *J Obstet Gynecol Neonatal Nurs*. 2010;39(4):480-488. doi:10.1111/j.1552-6909.2010.01159.x
38. Mielke R, Prepas R. When disaster strikes in rural America—call the midwife! *J Perinat Neonatal Nurs*. 2019;33(3):205-208. doi:10.1097/JPN.0000000000000417
39. Maher MJ. Emergency preparedness in obstetrics: meeting unexpected key challenges. *J Perinat Neonatal Nurs*. 2019;33(3):238-245. doi:10.1097/JPN.0000000000000421
40. Rivera FI. Puerto Rico's population before and after Hurricane Maria. *Popul Environ*. 2020;42(1):1-3. doi:10.1007/s11111-020-00356-4
41. Watkins DJ, Torres Zayas HR, Velez Vega CM, et al. Investigating the impact of Hurricane Maria on an ongoing birth cohort in Puerto Rico. *Popul Environ*. 2020;42(1):95-111. doi:10.1007/s11111-020-00345-7
42. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK. Births: final data for 2018. *Natl Vital Stat Rep*. 2019;68(13):1-47.
43. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: final data for 2017. *Natl Vital Stat Rep*. 2018;67(8):1-50.
44. Hamilton BE, Sutton PD, Mathews TJ, Martin JA, Ventura SJ. The effect of Hurricane Katrina: births in the US Gulf Coast region, before and after the storm. *Natl Vital Stat Rep*. 2009;58(2):1-28, 32.
45. Harville EW, Xiong X, David M, Buekens P. The paradoxical effects of Hurricane Katrina on births and adverse birth outcomes. *Am J Public Health*. 2020;110(10):1466-1471. doi:10.2105/AJPH.2020.305769
46. Smith AB. 2020 US billion-dollar weather and climate disasters in historical context. January 8, 2021. Updated September 27, 2021. Accessed October 18, 2021. https://www.climate.gov/news-features/blogs/beyond-data/2020-us-billion-dollar-weather-and-climate-disasters-historical
47. World Meteorological Organization. WMO atlas of mortality and economic losses from weather, climate and water extremes (1970-2019). WMO-no. 1267. 2021. Accessed April 4, 2022. https://library.wmo.int/doc_num.php?explnum_id=10989