

## Brief Report

**Cite this article:** Rivera-Gastón FA, Umpierre-Catinchi S, Ramos-Cartagena JM, et al. Treatment interruptions and mortality among Puerto Rican women with gynecologic cancers in Puerto Rico after Hurricanes Irma and María: A retrospective cohort study. *Disaster Med Public Health Prep.* 18(e105), 1–4. doi: <https://doi.org/10.1017/dmp.2024.108>.

### Keywords:

cancer survival; disasters; gynecologic cancer; hurricanes; treatment interruption



### Abbreviations:

PR, Puerto Rico; PRCCR, Puerto Rico Central Cancer Registry

### Corresponding author:

Ana P. Ortiz; Email: [ana.ortiz7@upr.edu](mailto:ana.ortiz7@upr.edu).

# Treatment Interruptions and Mortality Among Puerto Rican Women With Gynecologic Cancers in Puerto Rico After Hurricanes Irma and María: A Retrospective Cohort Study

Fabiola A. Rivera-Gastón MPH<sup>1</sup>, Sharee Umpierre-Catinchi MD<sup>2</sup>,  
Jeslie M. Ramos-Cartagena MS<sup>1</sup>, Karen J. Ortiz-Ortiz MA, MPH, DrPH<sup>1</sup>,  
Carlos R. Torres-Cintrón MPH<sup>1,3</sup>, Sandra I. García-Camacho MPH<sup>1</sup>,  
William A. Calo MPH, JD, PhD<sup>4,5</sup>, Guillermo Tortolero-Luna MD, PhD<sup>1</sup>,  
Liz M. Martínez-Ocasio MPH<sup>1</sup>  and Ana P. Ortiz MPH, PhD<sup>1,2</sup> 

<sup>1</sup>University of Puerto Rico Comprehensive Cancer Center, San Juan, Puerto Rico; <sup>2</sup>University of Puerto Rico, Medical Sciences Campus, San Juan, Puerto Rico; <sup>3</sup>Puerto Rico Central Cancer Registry, San Juan, Puerto Rico; <sup>4</sup>Penn State College of Medicine, Hershey, PA, USA and <sup>5</sup>Penn State Cancer Institute, Hershey, PA, USA

## Abstract

**Objective:** Cancer patients are among the most vulnerable populations during and after a disaster. We evaluated the impact of treatment interruption on the survival of women with gynecologic cancer in Puerto Rico following Hurricanes Irma and María.

**Methods:** A retrospective cohort study among a clinic-based sample of women with gynecological cancer diagnosed between January 2016 and September 2017 (n = 112) was done. Women were followed from their diagnosis until December 2019, to assess vital status. Kaplan-Meier survival curves and Cox proportional hazards models were performed.

**Results:** Mean age was 56 (± 12.3) years; corpus uteri (58.9%) was the most common gynecologic cancer. Predominant treatments were surgery (91.1%) and chemotherapy (44.6%). Overall, 75.9% were receiving treatment before the hurricanes, 16.1% experienced treatment interruptions, and 8.9% died during the follow-up period. Factors associated with treatment interruption in bivariate analysis included younger age (≤55 years), having regional/distant disease, and receiving > 1 cancer treatment (P < 0.05). Crude analysis revealed an increased risk of death among women with treatment interruption (HR: 3.88, 95% CI: 1.09–13.77), persisting after adjusting for age and cancer stage (HR: 2.49, 95% CI: 0.69–9.01).

**Conclusions:** Findings underscore the detrimental impact of treatment interruption on cancer survival in the aftermath of hurricanes, emphasizing the need for emergency response plans for this vulnerable population.

Gynecologic malignancies are among the cancers that affect most women in Latin America and the Caribbean. In 2020, the most common gynecologic cancers in the region were cervical, corpus uteri, and ovarian cancer, with age-standardized incidence rates of 14.9, 8.2, and 5.8 cases per 100 000 people, respectively.<sup>1</sup> In Puerto Rico (PR), gynecologic cancers represented 16% of all cancers diagnosed in women from 2016–2020.<sup>2</sup> The Puerto Rico Central Cancer Registry (PRCCR)<sup>2</sup> reported age-adjusted incidence rates (per 100 000 people) between 2016 and 2020 to be 30.0 for corpus uteri, 12.0 for cervical, and 7.8 for ovarian cancer. Considering women's role as primary caregivers, health outcomes in women extend to families and society, directly influencing the well-being of all.<sup>3</sup> This is particularly important in Puerto Rican culture, since for the period of 2017–2021, 46% of the households with children ages 0–17 years were headed by single mothers, and the median income among single mothers with children under 18 years was only US \$10,077.<sup>4</sup> These indicators highlight the key role of women in PR's society.

The aftermath of a natural disaster, such as a hurricane, presents great burdens and challenges, especially to those with chronic conditions. These challenges can include a disrupted health care system, communication difficulties, and loss of transportation services.<sup>5</sup> A recent study in PR documented the stressors and experiences of patients with gynecologic cancers after Hurricanes Irma and María and reported that disruptions in oncology care were common due to serious damage in the health care infrastructure, along with a lack of electricity and clean water.<sup>6</sup> Certain challenges, particularly those related to accessing medical care for cancer patients, directly correlate with anxiety, perceived stress, and post-traumatic symptomatology in the context of a natural disaster.<sup>7</sup> Previous studies have shown that lack of access to medical care

lead to treatment interruptions, that can also cause psychosocial and psychological distress in cancer patients, contributing to disease progression.<sup>7</sup>

Continual and uninterrupted cancer treatment is key for better outcomes or prognoses among cancer patients. Delays in treatment can have serious consequences on survival outcomes, including for gynecological cancers,<sup>5</sup> especially if the interruption is related to a natural disaster. In 2017, within 2 weeks, PR was hit by two catastrophic hurricanes: Irma (September 7, 2017—Category 5) and María (September 20, 2017—Category 4).<sup>8</sup> These hurricanes affected power systems, water supply, communications systems, and health systems, among other essential services, throughout the island.<sup>8</sup> During the months following the aftermath of Irma and María, the health system became inoperant.

Little is known about the potential increased risk of death among cancer patients in PR following the hurricane season of 2017. We aimed to evaluate the impact of treatment interruption on the survival of women with gynecologic cancer in PR following Hurricanes Irma and María.

## Methods

This retrospective cohort study included women diagnosed with gynecologic cancers before Hurricanes Irma and María hit PR, who reported receiving cancer treatment. Recruitment occurred through five gynecologic oncology clinics across the island, and physicians provided patient's contact information. After telephone-based informed consent was obtained from eligible women, they completed a telephone interview that assessed information about demographics, clinical and lifestyle characteristics, and the impact of the hurricanes on their treatment and health outcomes. If a participant was unable to give consent or had passed away, their caregiver was interviewed as a proxy. In total, 271 women were interviewed from September 2019 until November 2020. To confirm their cancer diagnosis and vital status, we matched the study's database with the PRCCR database. This match allowed us to confirm the date and age at the time of cancer diagnosis, type of cancer, tumor stage, vital status, and date of last contact (if a patient had passed away, this date corresponds to her death date). The PRCCR updated cancer patients' vital status by linking its database with the PR Demographic Registry Mortality File (cutoff—2019).

Gynecologic cancer types were assessed using the International Classification of Diseases for Oncology, third revision (ICD-O-3) codes: C510-C519; C529; C530-C539; C540-C549; C569; C570-C579. Out of 271 women, 259 (95.6%) matched with a cancer diagnosis, 3 were excluded due to a diagnosis outside of the gynecologic category, resulting in a sample of 256 participants. Fifty-four women were excluded due to pre-January 2016 diagnoses (less likely to be in active treatment), and one woman reported no cancer treatment, leaving a subsample of 201 women. From these, 112 were diagnosed before the hurricanes and 89 afterwards. Given the focus of the current work, our analysis included 112 women who were receiving cancer treatment and diagnosed with gynecologic cancer before the hurricanes (January 1, 2016–September 6, 2017). In terms of treatment, we first defined those in at least one treatment before the hurricanes (i.e., receiving treatment) using the following question: “Were you on this treatment BEFORE the hurricanes hit in September 2017?” Then, we defined treatment interruption based on whether they were receiving treatment or not, through this question: “Was this treatment interrupted because of Hurricanes Irma and María?”

The primary outcome of the study was vital status (dead or alive). As an indicator of treatment interruption, the main predictor variable was defined as the status of treatment at the time of the hurricanes, which was defined as (1) treatment completed (only had surgery) without reported interruption; (2) receiving treatment before the hurricanes and did not have interruption; and (3) receiving treatment before the hurricanes and had an interruption. In addition, this variable was also categorized into two categories that defined treatment interruption as a binary variable (yes or no). Other covariates of interest included age at the time of diagnosis (years), stage of cancer (localized, regional, distant), and type of gynecologic cancer—vulvar (C51), vaginal (C52), cervical (C53), corpus uteri (C54), ovarian (C56), and other female genital organs (C57).

A descriptive analysis using frequencies was performed to describe the sociodemographic and clinical variables of women who received cancer treatment. Factors associated with treatment interruption and vital status were evaluated using the Pearson's Chi-squared test or Fisher's exact test. A survival analysis was performed following the women from their date of cancer diagnosis until December 31, 2019, to evaluate survival after diagnosis. The follow-up period was determined by whether the women had passed away or not. If the event did not happen during the follow-up period, the data was censored until December 31, 2019. Kaplan-Meier survival curves were used to describe cancer survival by relevant covariates, and the Log-Rank test was used to indicate whether there was a statistically significant difference between the curves over time. Cox proportional hazards models were used to assess the crude and covariate-adjusted association between treatment interruption and vital status (dead or alive). Statistical significance was defined as  $P < 0.05$ .

The Institutional Review Board (IRB) of the University of Puerto Rico, Medical Sciences Campus (#A1810418), approved this study.

## Results

Most women had an age of diagnosis  $\geq 56$  years (58.0%), were unmarried (52.0%), had greater than a high school education (65.5%), earned a household family income  $\leq$  US \$19,999 (59.2%), and had public health care coverage (60.4%). Clinical variables showed that the most common gynecologic cancers in the study population were corpus uteri (58.9%), cervical (17.9%), and ovarian cancer (17.8%). On the other hand, vaginal (0.9%), vulvar (2.7%), and other gynecologic cancers (1.8%) were less common. Most women were diagnosed at localized stage (65.2%), followed by regional (25.9%) and distant (8.9%) stages. Regarding vital status, 8.9% of women diagnosed before the hurricanes died during the follow-up period (5 women with corpus uteri, 3 with cervical, and 2 with ovarian cancer) (data not shown).

With respect to treatment modalities, the most common were surgery (91.1%) and chemotherapy (44.6%), followed by brachytherapy (25.9%), radiotherapy (23.2%), and other treatments/alternative medicine (2.7%) (Table 1). Additionally, 56.3% of women received multiple or a combination of treatments. Overall, 75.9% of participants were receiving treatment before the hurricanes. However, although 21.2% of them were receiving treatment before the hurricanes and had interruptions, the treatments with more interruptions were chemotherapy (34.4%) and brachytherapy (33.3%) (see Table 1). Regarding treatment status at the time of the hurricanes for the overall study population ( $n = 112$ ), 16.1% of women receiving treatment before the

**Table 1.** Types of treatments and treatment interruption among women diagnosed before the hurricanes (n = 112)

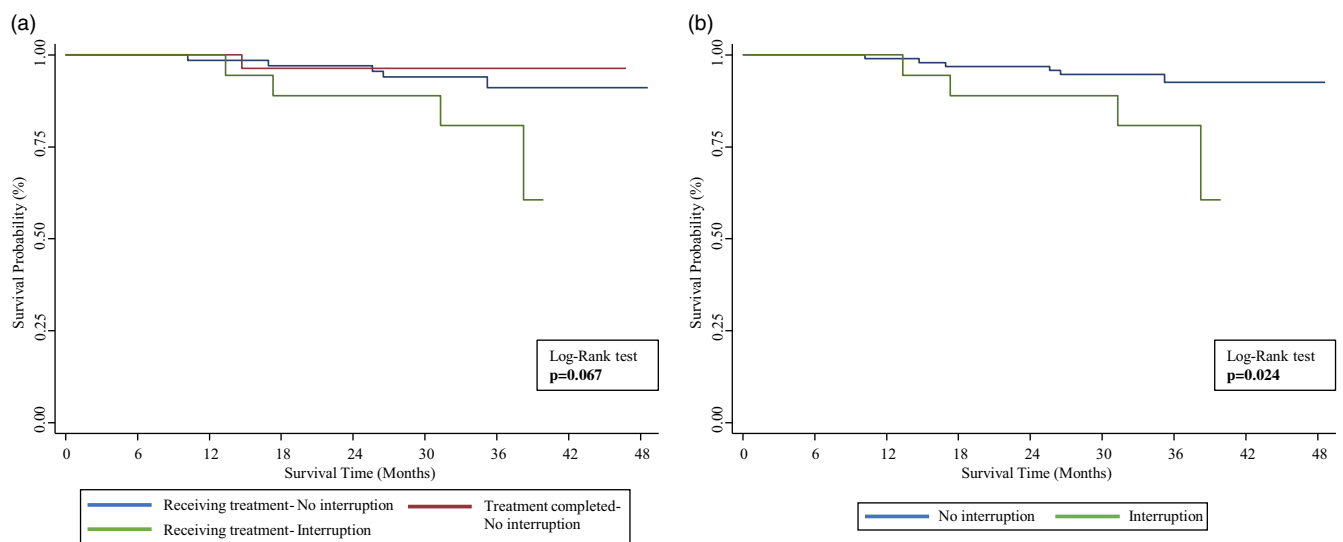
	Treatment					
	Received*		Received before the hurricanes**		Interruption as a result of the hurricanes***	
	n	%	n	%	n	%
Chemotherapy	50/112	44.6	32/50	64.0	11/32	34.4
Radiotherapy	26/112	23.2	13/26	50.0	5/26	19.2
Brachytherapy	29/112	25.9	12/29	41.4	4/12	33.3
Surgery	102/112	91.1	44/102	43.1	4/44	9.1
Other	3/112	2.7	1/3	33.3	1/1	100.0
Any treatment	112/112	100.0	85/112	75.9	18/85	21.2

\*Based on the study sample (n = 112).

\*\*Based on each individual treatment; women may have received more than 1 treatment.

\*\*\*Based on each treatment before the hurricanes.

Categories are not mutually exclusive.



**Figure 1.** Kaplan-Meier Survival Estimates for Treatment Status (n = 112).

hurricanes had treatment interruptions, while 83.9% did not. This last group included 24.1% of women from the study population who completed treatment (only had surgery) without any reported interruption, and 59.8% who were receiving treatment before the hurricanes who were not interrupted (data not shown).

On bivariate analysis, women who had treatment interruptions had higher proportions of being aged  $\leq 55$  years (66.7% versus 37.2%), diagnoses with regional/distant stage (55.6% versus 30.9%), and receiving more than one cancer treatment (83.3% versus 53.1%), compared to those without treatment interruptions ( $P < 0.05$ ). Concerning mortality, 22.2% of women with treatment interruptions died, compared to 6.4% of women without treatment interruptions ( $P < 0.05$ ) (data not shown).

Kaplan-Meier curves showed a clear overlap in the survival curves for women without treatment interruptions (those who completed treatment before the hurricanes and those receiving treatment but had no interruption) (Log-Rank test:  $P > 0.05$ ) (Figure 1a). When these categories were combined and this variable was dichotomized (no treatment interruption), a decrease in survival was observed in women with treatment interruptions as compared to those without treatment interruptions (Log-Rank test:  $P < 0.05$ ) (see Figure 1b). The Cox proportional model

showed an increased risk of death among women with treatment interruptions (HR: 3.88, 95% CI: 1.09–13.77). Although the model adjusted by age and cancer stage was not statistically significant, the magnitude of association persisted (HR: 2.49, 95% CI: 0.69–9.01) (data not shown).

### Discussion

This is the first study to document the impact of Hurricanes Irma and María on treatment interruptions among gynecologic cancer patients and their impact on disease outcomes in PR. Our study evidenced that over 16% of women in the study population had treatment interruptions due to the impact of Hurricanes Irma and María. Among specific treatments, brachytherapy and chemotherapy were the most interrupted (33%–34%). Lower interruptions in radiotherapy (19%) could be related to coordinated efforts of radiotherapy facilities in PR that aimed to reduce treatment interruptions among radiotherapy patients after the hurricanes.<sup>9</sup>

Study findings also showed a two- to threefold increased risk of death among women with treatment interruptions. This result is consistent with the literature since survival worsens as treatment interruptions occur and is consistent with the evidenced

detrimental effect of treatment interruptions on cancer patients, especially if the interruption occurs in the context of a natural disaster.<sup>5</sup> Future research should assess treatment delays, recognizing that the study evaluated treatment interruption exclusively in women diagnosed before the hurricanes. Such delays may substantially affect survival outcomes,<sup>5</sup> and could be linked to the damage in health care infrastructure that persisted in PR after the hurricanes.<sup>6</sup> Future research should also evaluate the impact of biopsychosocial variables on both treatment interruption and survival, as these factors have previously been shown to be associated.<sup>7</sup>

### Limitations

A limitation of this study is the reduced sample size, which may impact statistical power and generalizability. Additionally, information on treatment interruption was self-reported, and asked over two years after the events, posing the possibility of recall bias. Furthermore, women were interviewed once, with no follow-up interviews. However, a strength of this study was that the survival and other clinical characteristics were confirmed with the PRCCR database.

### Conclusion

The increased risk of death observed among gynecologic cancer patients who experienced treatment interruptions emphasizes the critical need for effective strategies to minimize treatment delays and ensure ongoing care post-disaster in this vulnerable population. Findings support the need for more infrastructure and disaster management plans in PR that should anticipate and prevent the interruption of treatment in cancer patients. As previously recommended by Ortiz *et al.*,<sup>10</sup> while emergency response plans should be housed within the emergency support function infrastructure of each state and territory in the United States, the Centers for Disease Control and Prevention's Comprehensive Cancer Control Plans provide an essential mechanism to support these efforts for cancer patients. At a local level, oncology clinics and care providers should establish emergency protocols for these events, which may include patients' contact information, alternative clinics, and access to medical information to ensure continuity of care. As the strength and frequency of natural disasters increases, emergency preparedness for cancer patients is vital.

**Author contributions.** Data collection: García-Camacho, Martínez-Ocasio, Ortiz, Torres-Cintrón. Methodology and design: Rivera-Gastón, Ortiz, Umpierre-Catinchi. Analysis and interpretation of data: Rivera-Gastón, Ramos-Cartagena, Ortiz-Ortiz, Ortiz. Drafting of the manuscript: Rivera-Gastón, Ortiz, Umpierre-Catinchi, Ramos-Cartagena. Critical revision of the manuscript: All authors. Statistical analysis: Rivera-Gastón, Ramos-Cartagena, Ortiz-Ortiz, Torres-Cintrón. Supervision: Umpierre-Catinchi, Ortiz.

**Funding statement.** This project was fully funded by the National Cancer Institute (NCI) Grant # 1R21CA239457-02 and supported by the Cancer Prevention and Control (CAPAC) Research Training Program (NCI Award Number R25CA240120) and a grant from the National Program of Cancer Registries (Grant #NU58DP007164) given to the Puerto Rico Central Cancer Registry (PRCCR) at the UPR Comprehensive Cancer Center.

**Competing interests.** The authors declare no conflicts of interest within the scope of this work.

### References

1. Estimated Age-Standardized Incidence Rates (World) in 2020, Latin America and the Caribbean, Females, All Ages (excl. NMSC). Global Cancer Observatory. Cancer Today. Published 2020. Accessed November 21, 2023. [https://gco.iarc.fr/today/online-analysis-multi-bars?v=2020&mode=cancer&mode\\_population=countries&population=900&populations=904&key=asr&sex=2&cancer=39&type=0&statistic=5&prevalence=0&population\\_group=0&ages\\_group%5B%5D=0&ages\\_group%5B%5D=17&nb\\_items=10&group\\_cancer=1&include\\_nmssc=0&include\\_nmssc\\_other=1&type\\_multiple=%257B%2522inc%2522%253Atrue%252C%2522mort%2522%253Afalse%252C%2522prev%2522%253Afalse%252D&orientation=horizontal&type\\_sort=0&type\\_nb\\_items=%257B%2522top%2522%253Atrue%252C%2522bottom%2522%253Afalse%252D#collapse-group-0-1](https://gco.iarc.fr/today/online-analysis-multi-bars?v=2020&mode=cancer&mode_population=countries&population=900&populations=904&key=asr&sex=2&cancer=39&type=0&statistic=5&prevalence=0&population_group=0&ages_group%5B%5D=0&ages_group%5B%5D=17&nb_items=10&group_cancer=1&include_nmssc=0&include_nmssc_other=1&type_multiple=%257B%2522inc%2522%253Atrue%252C%2522mort%2522%253Afalse%252C%2522prev%2522%253Afalse%252D&orientation=horizontal&type_sort=0&type_nb_items=%257B%2522top%2522%253Atrue%252C%2522bottom%2522%253Afalse%252D#collapse-group-0-1)
2. Puerto Rico Central Cancer Registry (PRCCR). Incidence case file from the Puerto Rico Central Cancer Registry at the University of Puerto Rico Comprehensive Cancer Center. PRCCR; 2023.
3. Onarheim KH, Iversen JH, Bloom DE. Economic benefits of investing in women's health: a systematic review. *PLoS One*. 2016;11(3):e0150120. doi: 10.1371/journal.pone.0150120
4. Estadísticas. Instituto del Desarrollo de la Juventud. Accessed November 9, 2023. <https://www.juventudpr.org/idj/estadisticas>
5. Man RXG, Lack DA, Wyatt CE, Murray V. The effect of natural disasters on cancer care: a systematic review. *Lancet Oncol*. 2018;19(9):e482-e499. doi: 10.1016/S1470-2045(18)30412-1
6. Calo WA, Rivera M, Mendez-Lazaro PA, *et al.* Disruptions in oncology care confronted by patients with gynecologic cancer following Hurricanes Irma and Maria in Puerto Rico. *Cancer Control*. 2022;29:107327482211146. doi: 10.1177/10732748221114691
7. Rodriguez-Rabassa M, Hernandez R, Rodriguez Z, *et al.* Impact of a natural disaster on access to care and biopsychosocial outcomes among Hispanic/Latino cancer survivors. *Sci Rep*. 2020;10(1):10376. doi: 10.1038/s41598-020-66628-z
8. Hurricanes Irma and Maria: Impact and Aftermath. RAND Corporation. Accessed November 9, 2023. <https://www.rand.org/hsrd/hsoac/projects/puerto-rico-recovery/hurricanes-irma-and-maria.html>
9. Gay HA, Santiago R, Gil B, *et al.* Lessons learned from Hurricane Maria in Puerto Rico: practical measures to mitigate the impact of a catastrophic natural disaster on radiation oncology patients. *Pract Radiat Oncol*. 2019;9(5):305-321. doi: 10.1016/j.prro.2019.03.007
10. Ortiz AP, Calo WA, Mendez-Lazaro P, *et al.* Strengthening resilience and adaptive capacity to disasters in cancer control plans: lessons learned from Puerto Rico. *Cancer Epidemiol Biomarkers Prev*. 2020;29(7):1290-1293. doi: 10.1158/1055-9965.EPI-19-1067