



# Underuse of Radiation Therapy After Breast Conservation Surgery in Puerto Rico: A Puerto Rico Central Cancer Registry–Health Insurance Linkage Database Study

## abstract

**Purpose** To identify rates of postoperative radiation therapy (RT) after breast conservation surgery (BCS) in women with stage I or II invasive breast cancer treated in Puerto Rico and to examine the sociodemographic and health services characteristics associated with variations in receipt of RT.

**Methods** The Puerto Rico Central Cancer Registry–Health Insurance Linkage Database was used to identify patients diagnosed with invasive breast cancer between 2008 and 2012 in Puerto Rico. Claims codes identified the type of surgery and the use of RT. Logistic regression models were used to examine the independent association between sociodemographic and clinical covariates.

**Results** Among women who received BCS as their primary definitive treatment, 64% received adjuvant RT. Significant predictors of RT after BCS included enrollment in Medicare (odds ratio [OR], 2.14; 95% CI, 1.46 to 3.13;  $P \leq .01$ ) and dual eligibility for Medicare and Medicaid (OR, 1.61; 95% CI, 1.14 to 2.27;  $P < .01$ ). In addition, it was found that RT was more likely to have been received in certain geographic locations, including the Metro-North (OR, 2.20; 95% CI, 1.48 to 3.28;  $P < .01$ ), North (OR, 1.78; 95% CI, 1.20 to 2.64;  $P < .01$ ), West (OR, 4.04; 95% CI, 2.61 to 6.25;  $P < .01$ ), and Southwest (OR, 2.79; 95% CI, 1.70 to 4.59;  $P < .01$ ). Furthermore, patients with tumor size  $> 2.0$  cm and  $\leq 5.0$  cm (OR, 0.61; 95% CI, 0.40 to 0.93;  $P = .02$ ) and those with tumor size  $> 5.0$  cm (OR, 0.37; 95% CI, 0.15 to 0.92;  $P = .03$ ) were found to be significantly less likely to receive RT.

**Conclusion** Underuse of RT after BCS was identified in Puerto Rico. Patients enrolled in Medicare and those who were dually eligible for Medicaid and Medicare were more likely to receive RT after BCS compared with patients with Medicaid alone. There were geographic variations in the receipt of RT on the island.

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## INTRODUCTION

The Commonwealth of Puerto Rico is an unincorporated territory of the United States with a population of approximately 3.6 million, primarily of Hispanic origin (98%). Breast cancer is the most common female malignancy in Puerto Rico,<sup>1</sup> and variations in breast cancer outcomes by geographic region and ethnic background<sup>2</sup> exist on the island. In the United States, disparities in the receipt of appropriate radiation therapy (RT) services have been identified,<sup>3-6</sup> and a lack of appropriate oncologic therapy may contribute to differences in cancer-related health outcomes

among racial and ethnic minorities.<sup>7-9</sup> However, little is known about whether variations in the receipt of guideline-recommended cancer care contribute to disparate breast cancer outcomes among patients in Puerto Rico.

Level I evidence indicates that for some women with early-stage invasive breast cancer treated with breast conservation surgery (BCS), RT reduces the risk of local recurrence and improves overall survival.<sup>13,14</sup> Thus, the use of RT in this setting has been used consistently as a quality indicator for appropriate oncologic care.<sup>15-17</sup> Claims-based studies have been long established

as a viable investigative approach to assessing population-based disparities in the receipt of cancer treatment modalities. However, many studies have used the SEER-Medicare linked databases.<sup>18-20</sup> The SEER-Medicare databases do not include Puerto Rico, and Hispanics are generally under-represented among the SEER regions that are included.<sup>21</sup> The goal of this study was to use the Puerto Rico Central Cancer Registry (PRCCR)–Health Insurance Linkage Database (HILD) to identify rates of postoperative RT after BCS in women with early-stage invasive breast cancer treated in Puerto Rico and to examine the sociodemographic and health services characteristics that may be associated with variations in receipt of RT.

## METHODS

### Data Source

We conducted this analysis using the PRCCR-HILD, which links insurance claims files with patients in the PRCCR. The PRCCR is financed by United States federal and state funds, and it covers all 78 municipalities in Puerto Rico. The PRCCR has been part of the United States National Program of Cancer Registries since 1997, and it uses the North American Association of Central Cancer Registries standards for coding data. In 2014, a Centers for Disease Control and Prevention evaluation estimated that for 2012, the completeness of case ascertainment was > 95.0%, comparable to the United States median (98.5%).<sup>22</sup>

PRCCR-HILD includes eligibility and claims data for approximately 60% of Puerto Rico's cancer cases for the period 2008 to 2012; these include three of the principal private health insurance

carriers and government health plan beneficiaries. Data in the PRCCR files are linked to the insurance claims files via encrypted person identifiers, and all data are de-identified so that no protected health information can be linked to individual patients. The process of linking claims from the health insurance databases was performed using a deterministic match with an algorithm similar to the one used by SEER-Medicare.<sup>23</sup> The MD Anderson Cancer Center and the University of Puerto Rico Medical Sciences Campus institutional review boards approved this study.

### Dependent Variables

We determined the proportion of patients who underwent BCS and who received external-beam RT within 12 months of the breast cancer diagnosis date from the insurance claims. RT and surgery codes are noted in the Data Supplement.

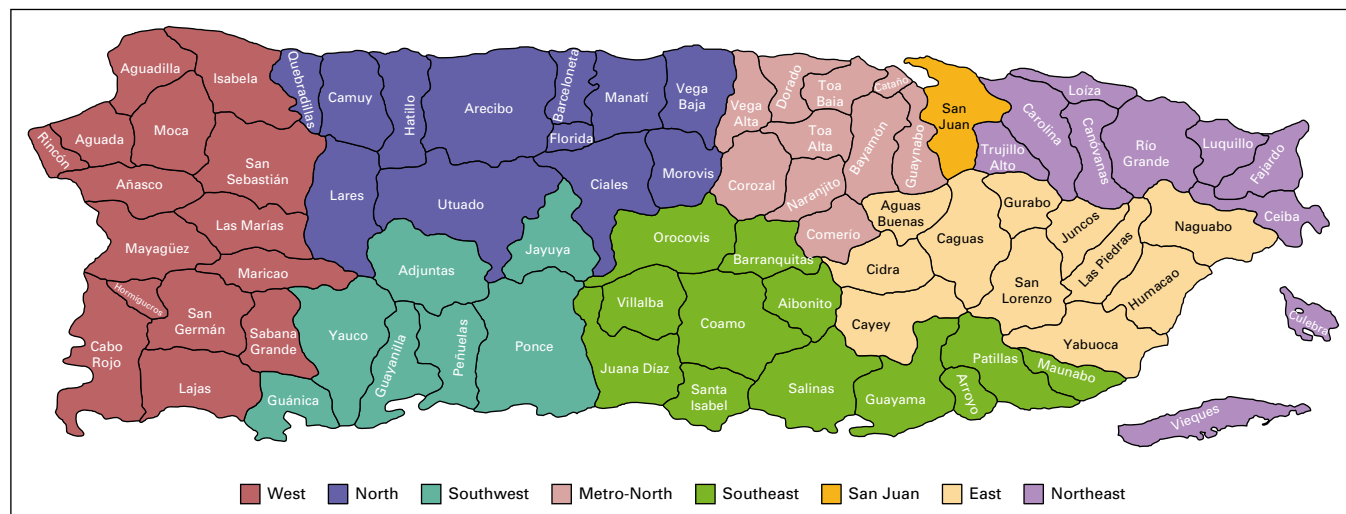
### Independent Variables

Independent variables in our analyses included demographic variables (age, geographic area of residence, marital status); diagnostic information (year of diagnosis as defined by the tumor registry); tumor variables (tumor size, nodal involvement); oncologic therapy (surgery type); and insurance type (private insurance, Medicaid, Medicare, or dually eligible). Geographic areas of Puerto Rico were based on Medicaid geographic service regions, as illustrated in Figure 1.

### Statistical Analyses

Statistical analyses were conducted using SAS software (version 9.4; Cary, NC). We performed a Cochran-Armitage test for trend to assess any

**Fig 1.** Medicaid geographic service regions of Puerto Rico.



significant change from 2008 to 2012 in the proportion of patients receiving RT. A multiple logistic regression model was used to examine the independent association between explanatory variables and the use of RT after BCS. Model fit statistics were examined by using Hosmer and Lemeshow's goodness-of-fit test. Final results are presented as odds ratios (ORs) with 95% CIs. All reported *P* values are two sided.

## RESULTS

### Cohort Definition

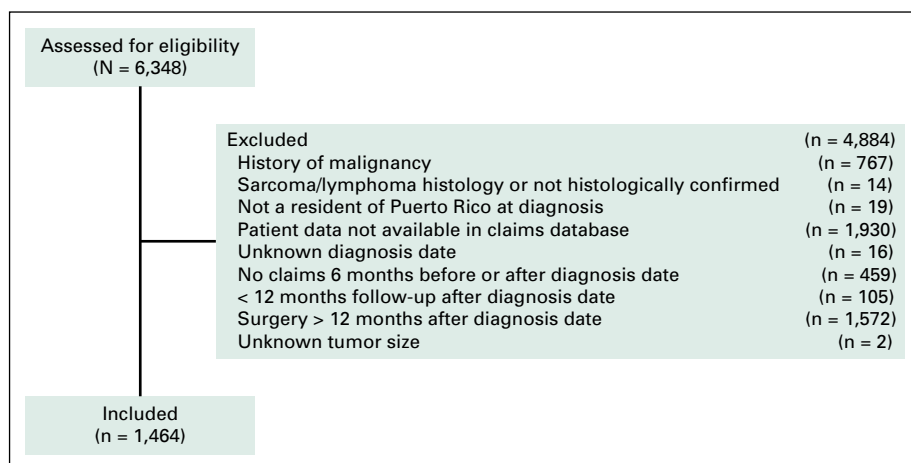
Figure 2 presents the algorithm for the development of this cohort. We queried the PRCCR database for patients diagnosed with invasive breast cancer between January 1, 2008, and December 31, 2012, as defined by International Classification of Diseases for Oncology, Third Edition, codes C500 to C509, excluding lymphomas and sarcomas (histology codes  $\geq$  8800). For this analysis, the breast cancer diagnosis date was defined as the date of the confirmed diagnosis recorded in the PRCCR. Cases reported to the PRCCR with unknown age or missing diagnosis date, those identified by death certificate only, or those without histologic confirmation of the diagnosis were excluded from the analysis. To limit our sample to early-stage invasive breast cancer, we only included cases with stage I or II disease at diagnosis as categorized using the American Joint Committee on Cancer (6th edition) for cases diagnosed before 2010 and 7th edition for cases diagnosed after 2010. Patients with a history of breast cancer or other malignancy were excluded. Primary breast cancer-directed surgery had to have occurred within 12 months of diagnosis as defined by the first Current Procedural Terminology–HCPCS code date. To prevent misclassification of the

intended primary surgery, patients who underwent mastectomy within 6 months of BCS without intervening RT were classified as having mastectomy. Patients with mastectomy between 6 and 12 months after BCS were excluded, given the inability to properly classify the primary surgery in these patients. To ensure we had adequate claims information to determine the patients' cancer treatment course and comorbidities, we excluded patients whose claims information was not available in the claims database and those with insurance providers with incomplete claims coverage (uninsured, Tricare, Military or Veterans Affairs, Indian or Public Health Service, or unknown insurance status). Insurance enrollment status was not available as a discrete variable in the PRCCR-HILD. Therefore, continuous insurance enrollment was estimated by evaluating for additional claims 6 months before and 6 months after the diagnosis date. Patients with no additional claims in this window were excluded. In addition, all patients with  $<$  12 months of claims data after diagnosis were excluded. Finally, patients characterized as undergoing mastectomy were excluded, to ensure that all patients in the cohort received BCS as the primary definitive treatment. A comparison between all patients with American Joint Committee on Cancer stage I or II breast cancer and the final cohort is presented in the Data Supplement.

### Patient Characteristics

Among the 1,464 women with stage I or II invasive breast cancer who received BCS as their primary definitive treatment 18% were  $\leq$  49 years old ( $n = 262$ ), 26% were between 50 and 59 years of age ( $n = 376$ ), 31% were between 60 and 69 years of age ( $n = 456$ ), and 25%

Fig 2. Cohort selection criteria.



were  $\geq 70$  years of age ( $n = 370$ ). With regard to the distribution of tumor size 28% had tumors  $< 1.0$  cm ( $n = 409$ ), 42% had tumors  $> 1.0$  cm and  $\leq 2.0$  cm ( $n = 619$ ), 28% had tumors  $> 2.0$  cm and  $\leq 5.0$  cm ( $n = 412$ ), and 2% had tumors  $> 5.0$  cm ( $n = 24$ ). Eighty percent of patients ( $n = 1,167$ ) had negative pathologic nodal evaluation; however, nodal status was unknown in 6% of patients ( $n = 84$ ). Forty-one percent of patients ( $n = 605$ ) were enrolled in Medicaid. Medicare patients and those dually eligible for Medicare and Medicaid represented 20% ( $n = 288$ ) and 23% ( $n = 339$ ), respectively. Sixteen percent of patients ( $n = 232$ ) were covered by private insurance (Tables 1 and 2).

### RT Receipt After BCS

Among the 1,464 women who received BCS as their primary definitive treatment, 64% were recorded as having received adjuvant RT (Tables 1 and 2). Patients older than 70 years of age with tumor size  $\leq 2$  cm and negative nodes were considered potentially observable after BCS. When these patients were excluded, 63%

received RT. The proportion of patients with stage I or II invasive breast cancer who received RT did not change significantly from 2008 to 2012 ( $P = .98$  for trend). An association with receipt of RT after BCS was seen with age, vital status, geographic region, tumor size, pathologic N stage, and insurance payer ( $P < .05$ ). Results of the multiple logistic model are listed in Table 3. Significant predictors of RT after BCS included enrollment in Medicare (OR, 2.14; 95% CI, 1.46 to 3.13;  $P \leq .01$ ) and dual eligibility for Medicare and Medicaid (OR, 1.61; 95% CI, 1.14 to 2.27;  $P < .01$ ). In addition, RT was more likely to have been received in certain geographic locations, including the Metro-North (OR, 2.20; 95% CI, 1.48 to 3.28;  $P < .01$ ), North (OR, 1.78; 95% CI, 1.20 to 2.64;  $P < .01$ ), West (OR, 4.04; 95% CI, 2.61 to 6.25;  $P < .01$ ), and Southwest (OR, 2.79; 95% CI, 1.70 to 4.59;  $P < .01$ ) regions of Puerto Rico. Furthermore, patients with tumor size  $> 2.0$  cm and  $\leq 5.0$  cm (OR, 0.61; 95% CI, 0.40 to 0.93;  $P = .02$ ) and those with tumor size  $> 5.0$  cm (OR, 0.37; 95% CI, 0.15 to 0.92;  $P = .03$ ) were found to be significantly less likely to receive RT. Pathologic N stage, age, marital status, and year of diagnosis were not found to be significant factors.

**Table 1.** Association Between Treatment Type and Clinical Characteristics

Characteristic	All Patients, No. (%)	No. (%)		P
		BCS Only	BCS and RT	
Surgery				—
BCS	1,464 (100)	520 (36)	944 (64)	
Age, years				.0279
20-49	262 (18)	95 (36)	167 (64)	
50-59	376 (26)	156 (41)	220 (59)	
60-69	456 (31)	150 (33)	306 (67)	
$\geq 70$	370 (25)	119 (32)	251 (68)	
Tumor size, cm				$< .001$
$\leq 0.5$	138 (9)	43 (31)	95 (69)	
$> 0.5$ and $\leq 1.0$	271 (19)	72 (27)	199 (73)	
$> 1.0$ and $\leq 2.0$	619 (42)	209 (34)	410 (66)	
$> 2.0$ and $\leq 5.0$	412 (28)	183 (44)	229 (56)	
$> 5.0$	24 (2)	13 (54)	11 (46)	
Pathologic N stage				.0298
N-	1,167 (80)	395 (34)	772 (66)	
N+	65 (4)	27 (42)	38 (58)	
Unknown	232 (16)	98 (42)	134 (58)	
Potentially observable				.0121
Yes	227	64 (28)	163 (72)	
No	1,237	456 (37)	781 (63)	

NOTE. Potentially observable defined as age  $\geq 70$  years, node negative, and tumor size  $\leq 2.0$  cm. Abbreviations: BCS, breast conservation surgery; RT, radiation therapy.

### DISCUSSION

In our study of women diagnosed with early-stage, invasive breast cancer in Puerto Rico, the rate of RT after BCS was 64%. Our analysis found that Puerto Rican patients enrolled in Medicare and those dually eligible for Medicaid and Medicare were more likely to receive RT after BCS, compared with patients with Medicaid alone. In addition, we identified geographic variations in treatment patterns, with women in the West, Southwest, North, and Metro-North regions more likely to receive RT after BCS.

To our knowledge, this is the first study to evaluate RT use in Puerto Rico; however, previous studies have identified disparate use of RT after BCS in the continental United States. Rates of RT after BCS in nonmetastatic breast cancer are approximately 86% in young women with employer-sponsored health insurance.<sup>25</sup> However, rates have been noted to be as low as 65% in nonwhite women enrolled in Medicare.<sup>26</sup> Specifically, African Americans and Hispanics have been associated with lower rates of RT after BCS compared with non-Hispanic white women.<sup>4</sup> The results of this study suggest underuse of RT in early-stage breast cancer

**Table 2.** Association Between Treatment Type and Demographic Characteristics

Characteristic	All Patients, No. (%)	No. (%)		P
		BCS Only	BCS and RT	
Diagnosis year				.5010
2008	182 (12)	66 (36)	116 (64)	
2009	211 (14)	68 (32)	143 (68)	
2010	312 (21)	122 (39)	190 (61)	
2011	348 (24)	117 (34)	231 (66)	
2012	411 (28)	147 (36)	264 (64)	
Region				< .001
West	216 (15)	41 (19)	175 (81)	
North	214 (15)	81 (38)	133 (62)	
Southwest	117 (8)	32 (27)	85 (73)	
Southeast	110 (8)	48 (44)	62 (56)	
San Juan	143 (10)	56 (39)	87 (61)	
Metro-North	228 (16)	67 (29)	161 (71)	
East	227 (16)	109 (48)	118 (52)	
Northeast	209 (14)	86 (41)	123 (59)	
Marital status				.1595
Unmarried	671 (46)	243 (36)	428 (64)	
Married	709 (48)	240 (34)	469 (66)	
Unknown	84 (6)	37 (44)	47 (56)	
Payer				< .001
Private insurance	232 (16)	82 (35)	150 (65)	
Medicaid	605 (41)	255 (42)	350 (58)	
Medicaid–Medicare	339 (23)	107 (32)	232 (68)	
Medicare	288 (20)	76 (26)	212 (74)	

Abbreviations: BCS, breast conservation surgery; RT, radiation therapy.

in Puerto Rico that is similar in magnitude to that of ethnic minority populations in the United States. The low rate of RT after BCS is concerning, given that adjuvant RT after BCS reduces the risk of local recurrence and may improve overall survival.<sup>13,14</sup>

The reasons for the underuse of RT identified in this study remain to be determined. Prior studies have shown that access to care and socioeconomic factors may influence disparities in breast cancer care in the United States.<sup>27,28</sup> Other factors, including provider interactions,<sup>29,30</sup> culturally specific health beliefs, and the presence or absence of social support,<sup>25,31</sup> could also affect the ability to receive care and may be important variables to explore in future studies seeking to better clarify specific barriers to appropriate breast cancer treatment in Puerto Rico. In addition, previous studies have identified geographic variations in breast cancer care in the United States.<sup>32,33</sup>

Although the reasons for these differences are likely multifactorial, rural and urban differences may play a role in the geographic variations in treatment. Prior studies have demonstrated that rural patients with breast cancer, especially those living farther from RT facilities, are less likely than their urban counterparts to receive guideline-recommended RT.<sup>34-36</sup> Detailed information on RT infrastructure, including information regarding the number of RT machines, technologic capabilities, the number of radiation oncologists, and the distribution of resources is not readily available for Puerto Rico. Therefore, the underlying cause of the geographic variations in receipt of RT in Puerto Rico warrants additional evaluation.

Variations in breast cancer treatment by health insurance in the United States have also been reported in past studies.<sup>37-39</sup> Our finding that women in Puerto Rico insured by Medicare were more likely to receive RT after BCS is in agreement with the findings of previous studies evaluating cancer care in the United States.<sup>9,38,40</sup> One possible explanation for this finding may be differences in patient characteristics and patient-specific factors (eg, comorbidities) among insurance plans. In addition, out-of-pocket expenses for a given plan and possible differences in physician recommendations on the basis of reimbursement schedules and incentives provided by health insurance plans could also play a role in the differences seen among insurance carriers.

This study demonstrates the feasibility of the use of the Puerto Rico Cancer Registry in health services research; however, there are several limitations to consider. First, this study does not represent a direct comparison between the population of Puerto Rico and that of the United States. Comparisons can only be inferred on the basis of previously published studies. Future studies could directly compare results from Puerto Rico with representative groups from the United States to better determine the magnitude of RT underuse and to evaluate for unique barriers to care that may exist in Puerto Rico. Second, not all insurance payers are currently linked to the PRCCR-HILD databases, limiting the scope and generalizability of the analysis. In particular, private payers are under-represented in the current analysis. PRCCR is currently working to expand the number of private insurance carriers available in the PRCCR-HILD, and future studies should be able to better identify the differences between private and public payers. Third, insurance



**Table 3.** Predictors of Receipt of Radiation Therapy After Breast Conservation Surgery

Characteristic	OR	95% CI	P
<b>Tumor size, cm</b>			
≤ 0.5	1.00		
> 0.5 and ≤ 1.0	1.25	(0.78 to 1.98)	.357
> 1.0 and ≤ 2.0	0.94	(0.62 to 1.42)	.765
> 2.0 and ≤ 5.0	0.61	(0.40 to 0.93)	.023
> 5.0	0.37	(0.15 to 0.92)	.033
<b>Pathologic N stage</b>			
N–	1.00		
N+	0.81	(0.48 to 1.38)	.441
Unknown	0.82	(0.60 to 1.11)	.196
<b>Age, years</b>			
20-49	1.00		
50-59	0.71	(0.50 to 1.00)	.050
60-69	0.81	(0.56 to 1.16)	.250
≥ 70	0.73	(0.48 to 1.13)	.155
<b>Marital status</b>			
Married	1.00		
Unmarried	0.97	(0.77 to 1.23)	.797
Unknown	0.71	(0.43 to 1.16)	.168
<b>Payer</b>			
Medicaid	1.00		
Medicare	2.14	(1.46 to 3.13)	< .001
Medicaid–Medicare	1.61	(1.14 to 2.27)	.007
Private insurance	1.35	(0.96 to 1.91)	.085
<b>Region</b>			
East	1.00		
Metro-North	2.20	(1.48 to 3.28)	< .001
North	1.78	(1.20 to 2.64)	.004
Northeast	1.32	(0.89 to 1.96)	.167
San Juan	1.32	(0.84 to 2.07)	.226
Southeast	1.37	(0.86 to 2.20)	.190
Southwest	2.79	(1.70 to 4.59)	< .001
West	4.04	(2.61 to 6.25)	< .001
<b>Diagnosis year</b>			
2008	1.00		
2009	1.12	(0.72 to 1.73)	.621
2010	0.87	(0.58 to 1.30)	.485
2011	1.06	(0.71 to 1.58)	.783
2012	1.00	(0.68 to 1.47)	.998

Abbreviation: OR, odds ratio.

enrollment status is not currently available in the PRCCR-HILD. Enrollment status was estimated by

determining whether claims had been made in a defined time interval; however, continuous insurance coverage could not be confirmed for patients included in the study. Missing claims resulting from incomplete insurance coverage could have resulted in an underestimation of treatment received for a given patient. Fourth, information on hormone receptor and human epidermal growth factor receptor 2 status is not currently available in the registry. The lack of estrogen receptor status limits our ability to select patients in whom omission of RT may have been appropriate. However, we did identify a potentially observable group defined by age, tumor size, and nodal status. Although exclusion of this group resulted in minimal changes in our results, definitive conclusions regarding how many patients were appropriately offered observation was not possible. Furthermore, reliable information on fractionation is not currently available in the database. Hypofractionation has the potential to be a powerful tool in addressing disparities in communities with limited access to radiation oncology resources, and adoption of hypofractionation techniques in Puerto Rico will be an important area of future study. Finally, comorbidity indices were not determined because of the limited numbers of patients with 12 months of claims before diagnosis and because of the inability to definitively confirm insurance enrollment status. Unaccounted-for differences among the study groups may exist, which may have influenced our reported outcomes.

In conclusion, our findings have the potential to significantly influence oncologic care in Puerto Rico by directing attention to the underuse of guideline-concordant care for early-stage breast cancer. Future studies should focus on better elucidating the barriers to cancer care and possible relevant interventions, including the use of hypofractionation techniques, intra-operative RT, and omission of RT for selected patients. In addition, this study is particularly timely, given the current economic and health care crisis in Puerto Rico. It is hoped that a more accurate definition of the current use of oncologic services will encourage policy experts to make informed decisions during any potential restructuring of governmental and health care resources.

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#### AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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