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Scientific Article

Expenditures and Use of Hypofractionated Radiation Therapy Treating Breast Cancer Among Medicare Advantage Enrollees, 2009 to 2017

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Purpose: Technology advances in cancer care have paralleled rapidly increasing expenditures in radiation therapy. The use and costs of shorter cancer radiation therapy offer potential utility in clinical practice. We evaluate use and expenditures of Medicare Advantage (MA) beneficiaries receiving hypofractionated whole breast irradiation (HF-WBI) compared with conventionally fractionated whole breast irradiation (CF-WBI) in the United States and examine the relationship of patient characteristics with HF-WBI use.

Methods and Materials: We performed a retrospective analysis of radiation therapy in MA beneficiaries using private employer-sponsored insurance claims for a pooled cross-sectional evaluation from 2009 to 2017. The study population included female MA beneficiaries with early-stage breast cancer treated with lumpectomy and whole breast irradiation.

Results: A total of 9957 women received HF-WBI, and 18,920 received CF-WBI. Older age, greater distance from home to treatment facility, and a higher proportion of college graduates in the community of residence were associated with increased HF-WBI use. Mean insurer-paid radiation therapy expenditures were significantly lower for HF-WBI versus CF-WBI (adjusted difference, $4113; 95% CI, $4030-$4,197). Mean patient out-of-pocket expenditure for HF-WBI was $426 less than that of CF-WBI. Across US states, geographic variation existed in the ratio of costs for HF-WBI relative to CF-WBI (range, 0.41-0.87).

Conclusions: HF-WBI use among MA beneficiaries with breast cancer has dramatically increased over time, surpassing CF-HBI as the dominant form of radiation therapy. HF-WBI clinical adoption has outpaced any continual cost decrease, despite wide variation across US states for this shorter radiation therapy treatment. As MA enrollment continues to expand, identifying the drivers of HF-WBI use and the sources of variation in costs of HF-WBI will help direct the quality of cancer care delivered to Medicare beneficiaries.

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Introduction

Hypofractionated whole breast irradiation (HF-WBI) is a shorter radiation therapy that provides higher doses of radiation per fraction, reducing treatment time. Randomized clinical trials[1-5] have shown HF-WBI's equivalence to the standard early-stage breast cancer treatment after breast-conserving surgery, conventionally fractionated whole breast irradiation (CF-WBI).[6] Despite these studies and a 2011 guideline released by the American Society for Radiation Oncology,[7] HF-WBI uptake has remained lower in the United States than expected, given

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the evidence of its cost effectiveness.[8,9] Rapidly increasing US health care expenditures[10] and health reform legislation to control runaway costs have drawn attention to innovations to support value-based cancer care.[11]

As the administrator of Medicare, the near-universal, national public health insurance program the Centers for Medicare and Medicaid Services (CMS) has actively promoted initiatives in Medicare to align financial incentives with the most valuable health care services.[11] Such CMS initiatives to remove the financial disincentives of volume-based care would be predicted to facilitate HF-WBI use broadly across the public and private insurance markets because Medicare is considered the model for insurance reimbursement. However, prior studies illustrate that although HF-WBI use has increased since 2011,[12-15] there is no evidence that financial disincentives have slowed the adoption of HF-WBI.[16]

Studies consistently demonstrate variation in radiation therapy costs within Medicare[10] and employer-sponsored private insurance,[15-17] the dominant form of health coverage in the United States. It is unknown how the use and costs for HF-WBI may vary for Medicare beneficiaries who have privately administered managed care plans through Medicare Advantage (MA). Private companies offer health plans in MA and typically administer Medicare Part A hospital insurance, Medicare Part B medical insurance, and Medicare Part D prescription drug coverage, in addition to other benefits not usually covered under Original Medicare, such as vision, hearing, or dental care (Medicare.gov). The goals of Medicare-managed care plans include reducing costs, improving choice, and enhancing quality.[18,19] Given its privatization, MA may be situated to incorporate innovations in care delivery and new technologies faster or more nimbly than publicly run Medicare plans.[20] MA enrollment has doubled since 2010, and currently, more than half of all eligible individuals with Medicare are enrolled in private MA plans.[21] Despite its burgeoning enrollment, previous studies have highlighted potential downsides of MA participation for patients, such as increased financial burden and limited provider networks.[22,23]

In this study, we assess the use and costs of HF-WBI and CF-WBI across MA health plans for their beneficiaries with breast cancer between 2009 and 2017. We also evaluate state-level variation across the Unites States in costs associated with the type of radiation therapy. To our knowledge, our study is the first to simultaneously investigate the use and variation in cost differences of breast radiation therapy across the Unites States within the MA market.

Methods and Materials

Data

The Health Care Cost Institute (HCCI; https://healthcostinstitute.org/about-hcci) is an independent, nonprofit entity consolidating employer-sponsored private insurance claims data from Aetna, Humana, Kaiser Permanente, and UnitedHealthcare. HCCI collects data covering about 55 million commercially insured individuals/year, making its data set a valuable research tool to investigate cancer care's current use and costs within private insurance. The data contain information on health services use, enrollment, health spending, and essential plan characteristics.

Study population

We identified women with incident breast cancer from the HCCI database 2009 to 2017 if they had at least 2 insurance claims with breast cancer diagnosis codes from the International Classification of Diseases, Ninth (ICD-9) and Tenth (ICD-10) revisions within 1 year and received whole breast irradiation after breast-conserving surgery according to Current Procedural Terminology (CPT) codes, as previously reported.[16] We excluded patients who started radiation therapy after August 31, 2017, because their radiation therapy course may have extended beyond the study period, preventing an accurate determination of the type of radiation therapy received. We further excluded patients with missing/incomplete information on radiation therapy delivery, men, and younger adults (<65 years) (Fig. E1). We included women with MA health insurance coverage by identifying women who were aged 65 years or older and who were also covered by a Medicare insurance plan within this private insurance claims database. The MA program is responsible for administering private Medicare plans.

Outcomes

The first outcome of interest was the use of HF-WBI versus CF-WBI. HF-WBI and CF-WBI were defined as receiving 15 to 24 radiation fractions and 25 to 40 fractions, respectively. If there was any ambiguity in the number of radiation fractions (11-14 or >40 fractions), we used days on radiation therapy to define HF-WBI (21-31 days) versus CF-WBI (39-120 days). Radiation therapy type was determined for 96.6% of patients based on radiation therapy fractions and for 3.4% using days on radiation therapy. The following outcomes evaluated were total, health plan (insurer), and patient out-of-pocket expenditures for respective radiation therapy strategies during 2009 to 2017. Health care expenditures for radiation therapy included the costs reflected in insurance claims for radiation therapy simulation, planning, physics, and delivery and management identified from CPT codes, as previously reported.[16] Patient out-of-pocket expenditures were the sum of deductibles, copayments, and coinsurance for the costs associated with radiation therapy, as indicated above. Total radiation therapy expenditures reflected the sum of total net insurer payments and patient out-of-pocket expenses, including deductibles, copayments, and coinsurance amounts. All financial outcomes represented expenses paid within 1 year of breast-conserving surgery and within 120 days after radiation therapy initiation. Expenditures were adjusted for inflation to reflect costs in 2017 US dollars.

Covariates

Covariates reflective of study population characteristics are shown in Table 1. Age in years reflected the age of women at the time of radiation therapy. The type of breast cancer diagnosis was either invasive or ductal carcinoma in situ. Receipt of chemotherapy was determined from CPT codes as previously reported.[16] Comorbid diseases were determined by adapting to the Charlson comorbidity index.[24,25] The relation to the employee (ie, the dominant health insurance policyholder) was categorized as the employee or a child/unknown. The types of employer-sponsored health plans evaluated included point-of-service (POS) plan, preferred provider organization (PPO), health maintenance organization (HMO), and private fee-for-service (PFF). According to the zip code of the patient's residence, community demographic features, including percentage of college graduates and poverty level, were obtained from US Census-level data.[26] Because the HCCI data do not include individual information on education and poverty level, our construction of these community-level variables was the most granular available in the analysis.

Data analysis

Multivariable logistic regression models were performed to evaluate the use of HF-WBI from 2009 to 2017, with the adjustment for year of radiation therapy, state of beneficiary health plan, age at the time of radiation therapy, stage of breast cancer diagnosis, receipt of chemotherapy, Charlson comorbidity index, community education level (% in the community with a college degree or higher), community poverty level (quartile), and type of insurance plan. All variables reflect data recorded at the time of radiation therapy. Adjusted odds ratios (aORs) with 95% CIs were calculated to indicate the strength of the association.

We also investigated total, insurer, and patient out-of-pocket expenditures for HF-WBI and CF-WBI over time by year and across US states. To analyze adjusted mean costs, we performed multivariable generalized linear models with gamma distribution and log-link adjusted for the covariates described above, excluding poverty level. Finally, we determined the average cost of each type of radiation therapy across US states and calculated the ratio of HF-WBI expenditure relative to CF-WBI expenditure. Alaska was excluded from cost analyses because of unreliable data from this state within the HCCI database. All analyses were conducted using Stata 15 (StataCorp LLC). Bonferroni-corrected *P* values <.05 were considered statistically significant.

Results

The final study cohort included 28,877 female patients aged 65 years or older with MA health insurance coverage (Table 1). Within this cohort, 9957 patients received HF-WBI, whereas 18,920 received CF-WBI during the study period. Most women receiving radiation therapy were in the 65-to-74-year age group. However, 3 of 10 patients receiving HF-WBI were in the older age group of 75 to 84 years. The majority of women with MA coverage receiving HF-WBI were enrolled in a PPO (57.5%) or an HMO (33.5%) insurance plan. Age, larger distance from home to the treatment facility, >40.4% of college graduates in the community, and higher income were associated with a higher likelihood of HF-WBI use (Table 2).

Table 3 shows that the mean insurer-paid radiation therapy expenditures were significantly lower for HF-WBI versus CF-WBI (adjusted difference, $4113; 95% CI, $4,030-$4,197). Mean patient out-of-pocket expenditure for HF-WBI was $426 less than that for CF-WBI. Unlike use trends, which have been inverted, insurer payments and patient out-of-pocket expenditures for CF-HBI were persistently higher than those for HF-WBI over time (Fig. 1). The average reduction in insurance payment was $275 per year for CF-WBI and $55 per year for HF-WBI; the decreasing trend was significant between the 2 types of radiation therapy. The average increase in the out-of-pocket payment was $9.7 per year for CF-WBI and $10.3 per year for HF-WBI, and the trend was similar between the 2 types of radiation therapy. Across US states (Fig. 2), geographic variation existed in average costs for HF-WBI relative to CF-HBI among MA beneficiaries, and the ratio ranged from 0.41 (Wyoming) to 0.87 (Washington, DC). Figure 2 illustrates that although CF-WBI expenditures were consistently greater than HF-WBI expenditures across US states, broad cost differentials between HF-WBI and CF-WBI exist across the country.

Discussion

In this study, we evaluated the use and costs of HF-WBI and CF-WBI among female MA enrollees with breast cancer between 2009 and 2017. Our results show that HF-WBI use has increased over time to represent the dominant form of breast cancer radiation therapy delivered to the MA population. The proportion of Medicare

Table 1 Characteristics of female breast cancer patients treated with radiation therapy with Medicare Advantage health coverage, 2008 to 2017

Characteristic	Type of radiation therapy CF-WBI (n = 18,920)	HF-WBI (n = 9957)
Age (y), no. (%)		
65-74	13,601 (71.9)	6630 (66.6)
75-84	4842 (25.6)	2971 (29.8)
85+	477 (2.5)	356 (3.6)
Type of breast cancer diagnosis, no. (%)		
Invasive	17,311 (91.5)	8707 (87.4)
Ductal carcinoma in situ	1609 (8.5)	1250 (12.6)
Chemotherapy, no. (%)		
Yes	5231 (27.6)	1138 (11.4)
No	13,689 (72.4)	8819 (88.6)
Charlson comorbidity index, no. (%)		
0	7261 (38.4)	2681 (26.9)
1	3267 (17.3)	1280 (12.9)
2	3300 (17.4)	2395 (24.1)
3+	5092 (26.9)	3601 (36.2)
Relation to employee, no. (%)		
Employee	12,209 (64.5)	6158 (61.8)
Child/Unknown	6711 (35.5)	3799 (38.2)
Type of health plan, no. (%)		
HMO	6464 (34.2)	3336 (33.5)
PFF	1737 (9.2)	488 (4.9)
POS	1088 (5.8)	411 (4.1)
PPO	9624 (50.9)	5720 (57.5)
Distance from home to treatment facility		
<5 miles	4918 (31.8)	2372 (27.6)
5-9.9 miles	3708 (24.0)	2002 (23.3)
10-49.9 miles	5613 (36.3)	3193 (37.2)
50+ miles	1226 (7.9)	1026 (11.9)
% of college graduates in community*		
<18.8%	4870 (26.7)	2144 (22.1)
18.8%-27.5%	4758 (26.0)	2221 (22.9)
27.6%-40.4%	4554 (24.9)	2442 (25.1)
>40.4%	4085 (22.4)	2911 (30.0)
Median age in community,* mean (SD)	40.8 (7.2)	40.5 (6.5)
% of under poverty line in community*		
<7.2%	4149 (22.7)	2849 (29.3)
7.2%-11.6%	4545 (24.9)	2449 (25.2)
11.7%-17.7%	4701 (25.7)	2295 (23.6)
>17.7%	4871 (26.7)	2125 (21.9)

Abbreviations: CF-WBI = conventionally fractionated whole breast irradiation; HF-WBI = hypofractionated whole breast irradiation; HMO = health maintenance organization; PFF = private fee-for-service; POS = point of service; PPO = preferred provider organization.
*Community demographic features based on zip code of patient's residence.
Charlson comorbidity index: higher values indicate greater comorbidity burden.

Table 2 Multivariable logistic regression model on receiving hypofractionated radiation therapy in Medicare Advantage patients 65 years and older*

	Adjusted OR (95% CI)	$\chi^{2‡}$
Insurance type		
HMO	1 (reference)	44.0
PFF	1.18 (1.03-1.35)	
POS	1.58 (1.36-1.85)	
PPO	1.15 (1.08-1.23)	
Age		
65-74	1 (reference)	73.9
75-84	1.29 (1.21-2.37)	
85+	1.53 (1.30-1.81)	
Chemotherapy		
No	1 (reference)	920.5
Yes	0.29 (0.27-0.31)	
Carlson comorbidity index		
0	1 (reference)	20.4
1	1.01 (0.93-1.11)	
2	1.02 (0.93-1.12)	
3+	0.87 (0.79-0.95)	
Distance from home to treatment facility		
<5 miles	1 (reference)	35.6
5-9.9 miles	1.09 (1.00-1.18)	
10-49.9 miles	1.19 (1.10-1.28)	
50+ miles	1.33 (1.20-1.49)	
% of college graduates in community†		
<18.8%	1 (reference)	63.0
18.8%-27.5%	1.05 (0.96-1.15)	
27.6%-40.4%	1.10 (1.00-1.20)	
>40.4%	1.44 (1.30-1.60)	
Median age in community† per 10-year increment	0.84 (0.80-0.88)	55.8
% of under poverty line in community†		
<7.2%	1 (reference)	32.9
7.2%-11.6%	0.90 (0.83-0.99)	
11.7%-17.7%	0.82 (0.74-0.90)	
>17.7%	0.73 (0.66-0.82)	

Abbreviations: HMO = health maintenance organization; OR = odds ratio; PFF = private fee-for-service; POS = point of service; PPO = preferred provider organization.
*Multivariable logistic regression model included all variables in the table at the time of radiation therapy and the year of radiation therapy.
†Community demographic features based on zip code of patient's residence.
‡All P values <.001 and χ^2 statistics used as a strength of statistical significance.

Table 3 Radiation therapy-related expenditures for breast cancer patients aged 65 years and older with Medicare Advantage insurance plans*

	Radiation therapy type		
Type of costs	**CF-WBI**	**HF-WBI**	**Differences, US dollars†**
*2009-2017 (adjusted mean [95% CI], US dollars†)			
Total costs	11,013 (10,948-11,078)	6458 (6403-6513)	4555 (4467-4643)
Insurers paid	9869 (9807-9931)	5755 (5703-5808)	4113 (4030-4197)
Patient OOP costs	1,096 (1080-1111)	669 (657-682)	426 (406-447)

Abbreviations: CF-WBI = conventionally fractionated whole breast irradiation therapy; HF-WBI = hypofractionated whole breast irradiation.
*Multivariable generalized linear models with gamma distribution and log link, with the adjustment for year of radiation therapy, state of beneficiary health plan, age at the time of radiation therapy, type of breast cancer diagnosis, receipt of chemotherapy, Charlson comorbidity index, community education level (% in the community with a college degree or higher), and type of insurance plan. All the differences were statistically significant with $P < .0001$.
†All expenditures were rounded up to the nearest dollar amount in 2017 US dollars after adjusting for inflation.

beneficiaries enrolled in privately administered MA plans has been steadily increasing for decades, and if trends continue, the majority of Medicare patients will soon receive their health insurance benefits and, by extension, their cancer care, through MA plans.[21] Prior research on HF-WBI use in the private commercial insurance market showed slower uptake comparatively, where HF-WBI still lags behind conventional radiation therapy.[15-17] The underlying causes of this differential uptake and the extent to which adoption rates could be attributed to disparities in access to HF-WBI requires further characterization in future research. Prior work found no differences in health care access and preventive care for low-income adults enrolled in MA compared with those who were enrolled in traditional Medicare plans.[27] This study also indicated that the cost burdens associated with medical

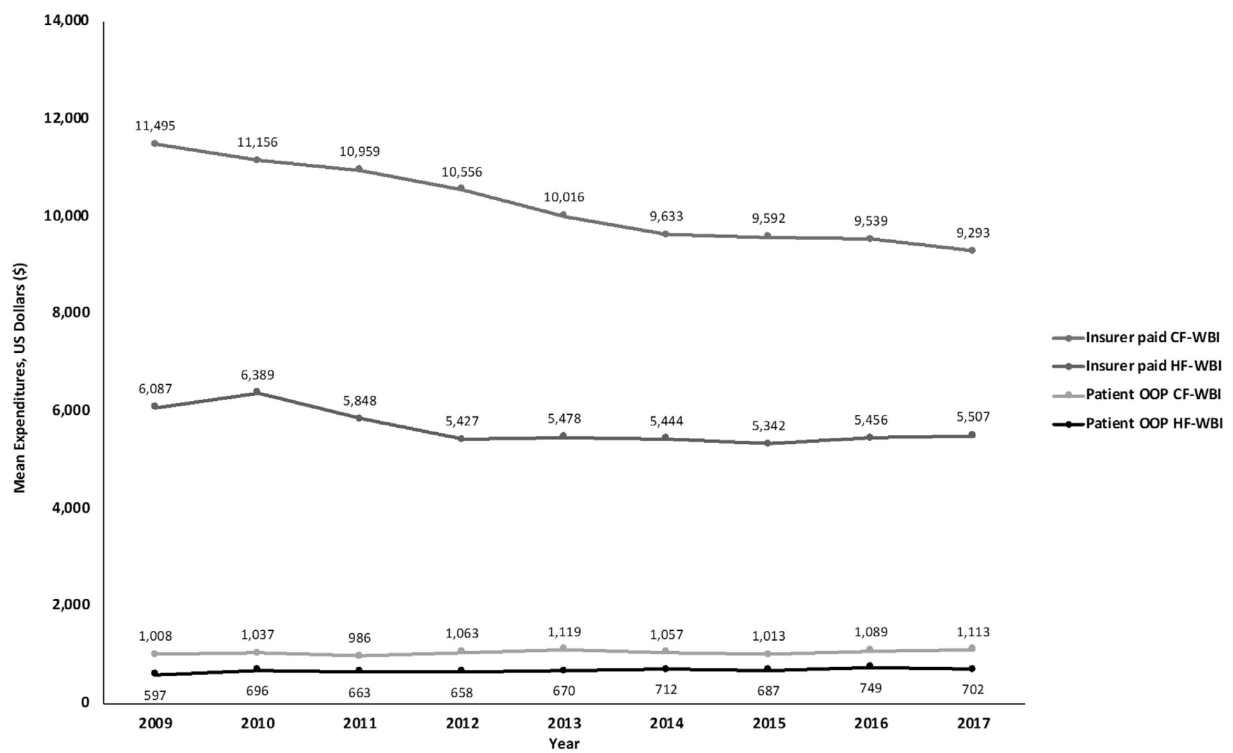

Figure 1 Trend of radiation therapy-related expenditures for breast cancer patients aged 65 years and older with Medicare Advantage insurance plans.

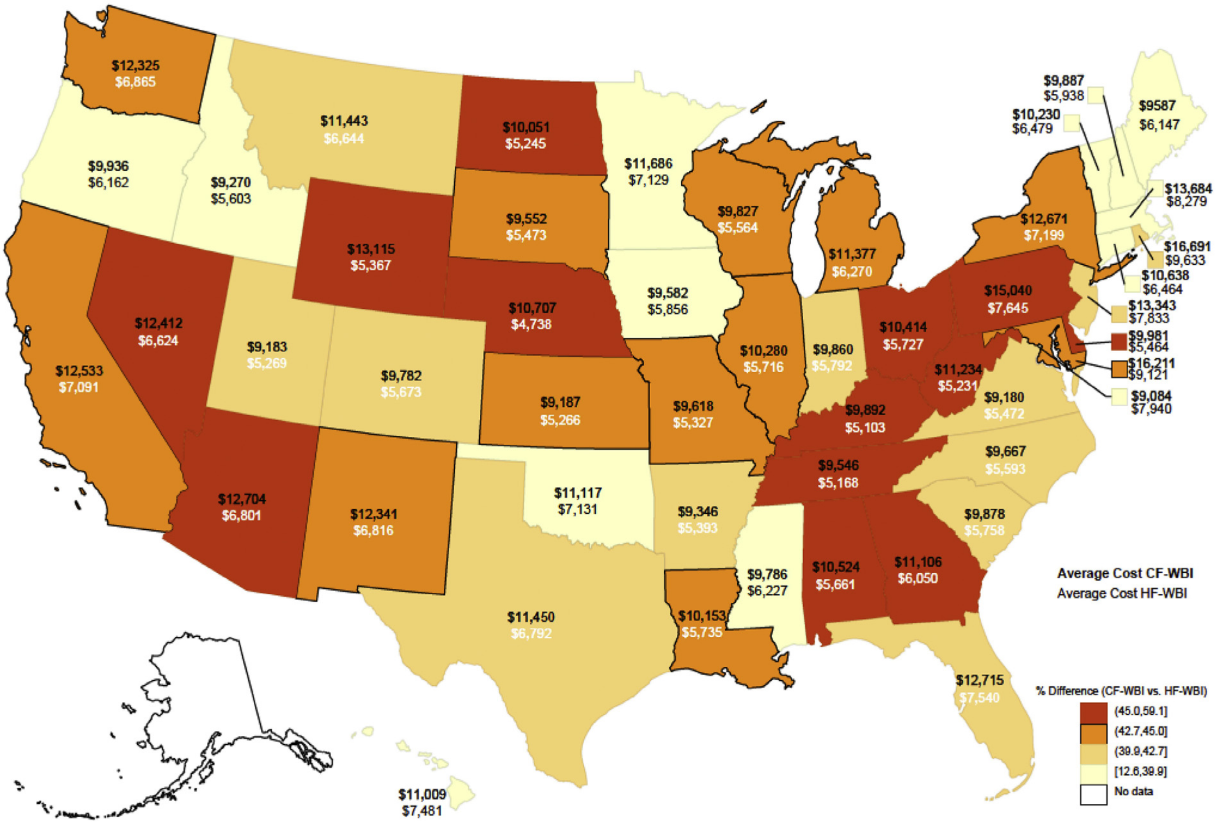

Figure 2 Average costs reflect 2017 US dollars of CF-WBI relative to HF-WBI in women with breast cancer by state, 2008 to 2017. Alaska is excluded because of unreliable data for the state. The colors on the map represent ranges for the percent difference in average costs between CF-WBI and HF-WBI delivered to female Medicare Advantage beneficiaries. The color gradient from red to white, respectively, corresponds to the range of high to low percent difference in average costs between CF-WBI and HF-WBI.
Abbrevations: CF-WBI = conventionally fractionated whole breast irradiation; HF-WBI = hypofractionated whole breast irradiation.

care and prescription drugs were similar between these groups. Major initiatives and levers that would facilitate HF-WBI use have been initiated in the Medicare program, which may partially relate to accelerating the adoption of HF-WBI in MA.[28] Furthermore, because Medicare is a national health insurance program, these efforts may possibly be leveraged to address disparities in the uptake of HF-WBI.[12,29-32]

Similar to prior studies,[15,16] we found that the expenditures of both insurers and patients were lower for HF-WBI use than for CF-WBI use. In addition, we observed greater cost savings in patient out-of-pocket expenses when treated with HF-WBI for MA beneficiaries (cost reduction of $426), compared with patients in the private commercial insurance market ($139).[16] This could have meaningful implications for patients regarding reducing the financial toxicity of cancer treatment.[33]

Variation with no particular pattern was observed in cost differences between HF-WBI and CF-WBI across US states. Earlier studies have evaluated regional geographic variation of HF-WBI use within the Medicare population,[34] yet they excluded MA (ie, privatized managed care), representing a select group of health plans. Although earlier research has shown that private commercial health care spending is related to market structure and that the reduction of provider market concentration would likely facilitate cost reductions within private markets,[35] it is unclear to what extent these findings would be reflected within MA when considering costs of radiation therapy. This study expands the currently limited evidence base on the geographic variation in average costs for HF-WBI compared with CF-WBI that will likely impact the expenditures of MA beneficiaries and their insurers.

Other studies have investigated physician-level characteristics, such as practice type, on use and cost variation in HF-WBI.[32,34,36-38] Although the HCCI database does not include granular physician information, which may influence physician preference for HF-WBI, we have previously quantified the overall variation across radiation oncologists.[30] Future studies that comprehensively delineate the impact of physician and practice traits on use and costs in MA are critically important, given the rapid increase in MA enrollment.[21]

This study has limitations. Our evaluation may not be generalizable to other types of insured populations because we only focused on women receiving radiation therapy who have health insurance coverage through MA. We also lack available data on the details of the benefit structure for each beneficiary's health plan, which prevents identifying any specific plan features that might incentivize or influence HF-WBI use and costs. For example, utilization management, which restricts reimbursement for conventional therapy if the fully insured woman is eligible for hypofractionated radiation therapy, has increased the use of HF-WBI in MA plans among early-stage breast cancer patients.[28]

Prior research has shown various disadvantages associated with MA coverage. One study found that MA beneficiaries were more likely to report financial strain and have difficulty paying for their medical bills than those with traditional Medicare.[22] Another found that for private Medicare plan networks within MA, 1 in 5 plans have no academic medical center in-network, and that among plans in an area with a National Cancer Institute-designated cancer center, more than 2 in 5 did not include the cancer center in their network.[23] These studies could indicate limitations in the type of cancer care accessible to MA beneficiaries, given that academic cancer programs were most likely to administer HF-WBI.[39]

Our analysis determined that MA beneficiaries spent less on average when receiving HF-WBI than CF-WBI. These potential cost reductions for MA beneficiaries receiving HF-WBI merit future research further delineating the drivers of HF-WBI use and the sources of variation in costs of HF-WBI to help ensure the quality of cancer care delivered to Medicare-managed care beneficiaries.

Disclosures

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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