

## Research Letter

# Worsening Racial Disparities in Utilization of Intensity Modulated Radiation Therapy

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## Abstract

**Purpose:** The benefits of intensity modulated radiation therapy (IMRT) compared with standard 3-dimensional conformal radiation therapy have been demonstrated in many cancer sites and include decreased acute and late toxicity, improved quality of life, and opportunities for dose escalation. Limited literature suggests non-white patients may have lower utilization of IMRT. We hypothesized that as the use of IMRT has increased in recent years, racial inequities have persisted and disproportionately affect non-Hispanic Black (NHB) patients. We aim to evaluate temporal trends in IMRT utilization focusing on disparities among minoritized populations.

**Methods and Materials:** The National Cancer Database was queried to identify the 10 disease sites with the highest total number of cancer patients treated with definitive intent IMRT in 2017, the most recent year for which data are available. Exclusions included stage IV, age <18 years, unknown insurance status, unknown race, and palliative intent radiation. Race and ethnicity variables were combined and classified as non-Hispanic White, Hispanic, NHB, Asian, Native American/Eskimo, and Hawaiian/Pacific Islander. Multivariable logistic regression for IMRT utilization was performed for each disease site for both early (2004-2010) and contemporary (2011-2017) cohorts, adjusting for clinical and demographic covariates.

**Results:** Among the 10 selected disease sites, 1,010,292 patients received radiation therapy as part of definitive treatment between 2004 and 2017. Overall IMRT utilization rates increased from 22.0% in 2004 to 57.8% in 2017. After adjustment and compared with non-Hispanic White patients, NHB patients were significantly less likely to receive IMRT in 1 of 10 disease sites in the 2004 to 2010 cohort, and 5 of 10 disease sites in the 2011 to 2017 cohort.

**Conclusions:** Despite greater awareness of racial disparities in cancer care and outcomes, this study demonstrates worsening disparities in the use of IMRT, particularly for NHB patients. These differences may exacerbate racial disparities in cancer outcomes; therefore, identification of underlying drivers of differential IMRT utilization is warranted.

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Research data are from a publicly available data set and are therefore not available from the authors of this article.

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## Introduction

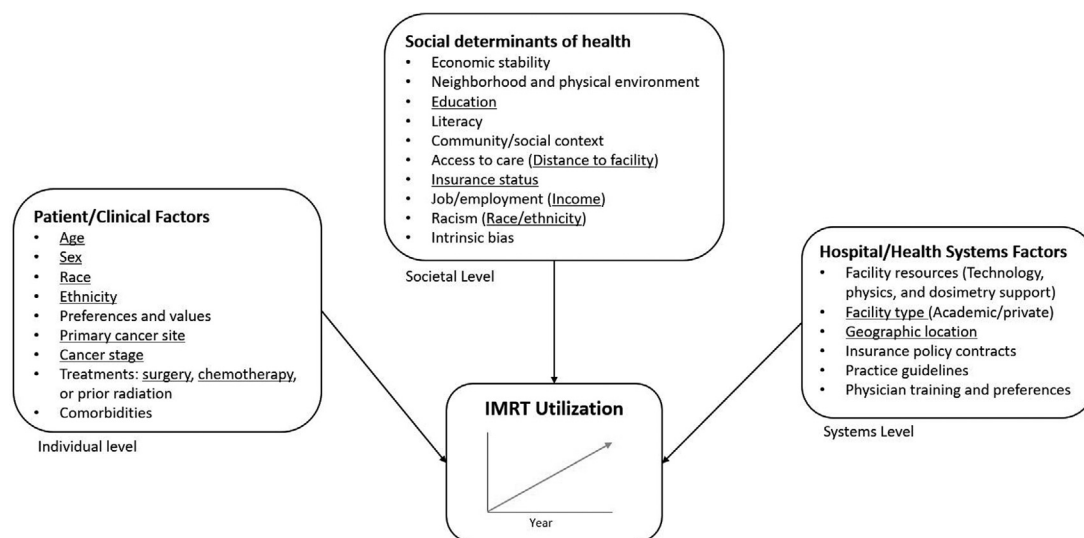
Although non-Hispanic Black (NHB) patients have had the highest cancer incidence and mortality of any racial and ethnic group in the United States for more than 4 decades, lower use of curative intent medical interventions including radiation therapy (RT) has been reported across multiple disease sites compared with non-Hispanic White (NHW) patients.<sup>1,2</sup> The developments of image guided radiation therapy and intensity modulated radiation therapy (IMRT) have significantly improved the ability to shape radiation dose to deliver high doses to target volumes while minimizing dose to adjacent organs. Although the first commercially available IMRT platform was released in 1992, this technology was not widely adopted until recently with access to, and utilization rates of, IMRT varying widely throughout the United States.<sup>3</sup> The benefits of IMRT compared with standard 3-dimensional conformal radiation therapy have been demonstrated in many cancer sites and include decreased acute and late toxicity, improved quality of life, and opportunities for dose escalation.<sup>4-8</sup>

A paucity of literature suggests that non-white patients have lower utilization rates of IMRT.<sup>9-13</sup> Underlying reasons for this disparity have not been clearly established. The relationship between increasing IMRT utilization rates and worsening disparities has not been previously reported. Given persistently poor oncologic outcomes in non-white patients and inequitable distribution of advanced radiation technologies,<sup>2,14</sup> we hypothesized that as use of IMRT has increased in recent years, racial inequities have persisted and disproportionately affect Black patients, who also have worse cancer

outcomes. We aimed to evaluate temporal trends in IMRT utilization while focusing on racial and ethnic disparities.

## Methods and Materials

The National Cancer Database was queried to identify the 10 disease sites with the highest total number of patients with cancer treated with definitive intent IMRT in 2017, the most recent year for which data are available. The 10 disease sites included were prostate, head and neck, lung, brain, rectum, esophagus, uterus, anus, cervix, and stomach. We excluded other primary disease sites, unknown race, stage IV disease, age <18 years, unknown insurance status, palliative intent radiation. Race and ethnicity were classified as NHW, NHB, Hispanic, Asian, Native American/Eskimo, and Hawaiian/Pacific Islander. Annual rates of IMRT utilization are reported as percentages of total cases by disease site. A conceptual model incorporating individual, societal, and systems-level factors contributing to IMRT utilization, as well as corresponding variables available through NCDB is depicted in [Figure 1](#). Multivariable logistic regression for IMRT utilization was performed for each disease site for both early (2004-2010) and contemporary (2011-2017) cohorts. Models were adjusted for stage group (I, II, III), age group (<45 years, 45-65 years, >65 years), sex (male, female), race or ethnicity (NHW, NHB, Hispanic, Asian, Native American/Eskimo, Native Hawaiian/Pacific Islander), income quartiles (first, second, third, fourth), education quartiles (first, second, third, fourth), insurance status (uninsured, private, Medicaid, Medicare, other government), great circle distance (<50



**Fig. 1** Conceptual model for factors contributing to IMRT utilization. Variables available from the National Cancer Database and included in our analysis are underlined. *Abbreviation:* IMRT = intensity modulated radiation therapy.

miles, 50-200 miles, >200 miles), treatment facility type (community, comprehensive community, academic/research, integrated), geographic region (Northeast, South, Midwest, West), use of chemotherapy (yes or no), and use of surgery (yes or no). An exploratory analysis was performed to examine the association between insurance status and use of IMRT by race or ethnicity. This study is exempt from institutional review board approval.

### Results

Patient clinical and sociodemographic information are summarized in Table 1. In total, 1,010,292 patients received radiation therapy to the included disease sites as part of definitive treatment between 2004 and 2017, with 485,340 of patients (48.0%) receiving IMRT. Overall IMRT utilization rates increased from 21.98% in 2004 to 57.8% in 2017. Rates of IMRT utilization during the study period for each

**Table 1 Patient sociodemographic and clinical characteristics**

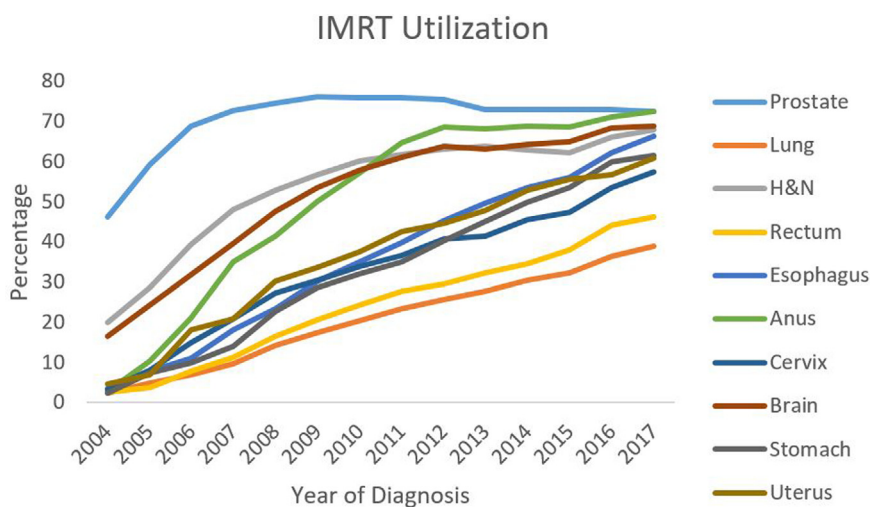
| Primary site group               | 3D CRT  |      | IMRT    |      | P value |
|----------------------------------|---------|------|---------|------|---------|
|                                  | Number  | %    | Number  | %    |         |
| H&N                              | 50,802  | 44.1 | 64,403  | 55.9 | <.001   |
| Esophagus                        | 21,466  | 58.1 | 15,509  | 41.9 |         |
| Stomach                          | 11,975  | 60.0 | 7975    | 40.0 |         |
| Rectum/sigmoid                   | 53,553  | 72.8 | 20,020  | 27.2 |         |
| Anus                             | 12,902  | 42.6 | 17,417  | 57.4 |         |
| Lung                             | 210,222 | 76.1 | 66,192  | 23.9 |         |
| Cervix                           | 17,973  | 64.0 | 10,088  | 36   |         |
| Uterus                           | 12,921  | 59.0 | 8962    | 41   |         |
| Prostate                         | 90,400  | 28.9 | 222,263 | 71.1 |         |
| Brain                            | 42,738  | 44.9 | 52,511  | 55.1 |         |
| Year of diagnosis                |         |      |         |      |         |
| 2004-2008                        | 184,264 | 63.2 | 107,387 | 36.8 | <.001   |
| 2009-2013                        | 182,924 | 49.8 | 184,511 | 50.2 |         |
| 2014-2017                        | 157,764 | 44.9 | 193,442 | 55.1 |         |
| Clinical stage                   |         |      |         |      |         |
| I                                | 151,336 | 69.3 | 67,071  | 30.7 | <.001   |
| II                               | 159,937 | 39.7 | 243,415 | 60.3 |         |
| III                              | 171,742 | 58.4 | 122,419 | 41.6 |         |
| Age (y)                          |         |      |         |      |         |
| <45                              | 25,910  | 53.5 | 22,485  | 46.5 | <.001   |
| 45-65                            | 210,050 | 50.9 | 202,812 | 49.1 |         |
| >65                              | 288,992 | 52.6 | 260,043 | 47.4 |         |
| Sex                              |         |      |         |      |         |
| Male                             | 321,109 | 46.7 | 367,152 | 53.3 | <.001   |
| Female                           | 203,843 | 63.3 | 118,188 | 36.7 |         |
| Race/ethnicity group             |         |      |         |      |         |
| Non-Hispanic White               | 426,665 | 52.5 | 385,310 | 47.5 | <.001   |
| Hispanic                         | 18,667  | 48.4 | 19,905  | 51.6 |         |
| Non-Hispanic Black               | 58,948  | 49.3 | 60,653  | 50.7 |         |
| Asian                            | 11,582  | 52.3 | 10,574  | 47.7 |         |
| Native American/Eskimo           | 1583    | 55.4 | 1272    | 44.6 |         |
| Native Hawaiian/Pacific Islander | 393     | 54.7 | 325     | 45.3 |         |
| Other                            | 7114    | 49.4 | 7301    | 50.6 |         |

(continued on next page)

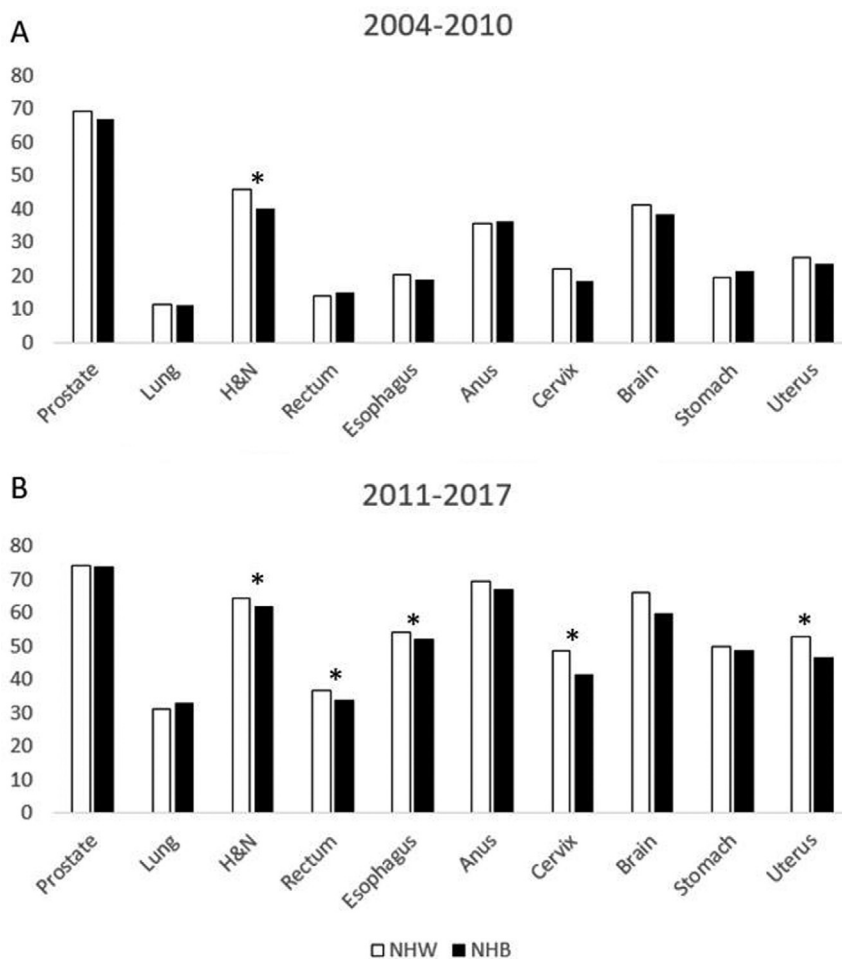
**Table 1** (Continued)

| Primary site group                                   | 3D CRT  |      | IMRT    |      | P value |
|--|---------|------|---------|------|---------|
|  | Number  | %    | Number  | %    |         |
| Median income quartiles                              |         |      |         |      |         |
| <\$40,227  | 101,142 | 55.2 | 82,233  | 44.8 | <.001   |
| \$40,227-\$50,353                                    | 112,174 | 53.0 | 99,389  | 47   |         |
| \$50,354-\$63,332                                    | 111,576 | 51.6 | 104,676 | 48.4 |         |
| ≥\$63,333  | 160,542 | 51.8 | 149,232 | 48.2 |         |
| Percentage of residents without a high school degree |         |      |         |      |         |
| ≥17.6%   | 106,665 | 55.3 | 86,116  | 44.7 | <.001   |
| 10.9%-17.5%  | 135,318 | 54.2 | 114,288 | 45.8 |         |
| 6.3%-10.8%   | 136,445 | 51.7 | 127,294 | 48.3 |         |
| <6.3%  | 108,067 | 49.8 | 108,773 | 50.2 |         |
| Primary insurance                                    |         |      |         |      |         |
| Not insured  | 15,571  | 56.7 | 11,901  | 43.3 | <.001   |
| Private insurance                                    | 179,373 | 50.6 | 175,116 | 49.4 |         |
| Medicaid   | 33,944  | 53.1 | 29,991  | 46.9 |         |
| Medicare   | 284,082 | 52.8 | 254,387 | 47.2 |         |
| Other government                                     | 11,982  | 46.2 | 13,945  | 53.8 |         |
| Distance from treatment facility (miles)             |         |      |         |      |         |
| <50  | 449,068 | 52.6 | 404,098 | 47.4 | <.001   |
| 50-200   | 36,834  | 54.3 | 31,038  | 45.7 |         |
| >200   | 5420    | 48.9 | 5667    | 51.1 |         |
| Facility type  |         |      |         |      |         |
| Community cancer program                             | 51,784  | 56.2 | 40,297  | 43.8 | <.001   |
| Comprehensive community cancer program               | 218,607 | 51.5 | 206,259 | 48.5 |         |
| academic/research program                            | 175,382 | 52.3 | 159,946 | 47.7 |         |
| Integrated   | 65,449  | 49.9 | 65,674  | 50.1 |         |
| Geographic region                                    |         |      |         |      |         |
| Northeast  | 113,737 | 50.9 | 109,797 | 49.1 | <.001   |
| South  | 189,422 | 53.7 | 163,456 | 46.3 |         |
| Midwest  | 136,889 | 50.9 | 132,110 | 49.1 |         |
| West   | 71,174  | 51.6 | 66,813  | 48.4 |         |
| Chemotherapy usage                                   |         |      |         |      |         |
| No chemo   | 255,309 | 47.0 | 288,040 | 53   | <.001   |
| Chemo  | 269,643 | 57.7 | 197,300 | 42.3 |         |
| Surgery  |         |      |         |      |         |
| No surgery   | 372,175 | 51.9 | 344,610 | 48.1 | <.001   |
| Neoadjuvant RT                                       | 54,171  | 68.1 | 25,354  | 31.9 |         |
| Adjuvant RT  | 98,606  | 46.1 | 115,376 | 53.9 |         |

Abbreviations: 3D CRT = 3-dimensional conformal radiation therapy; H&N = head and neck; IMRT = intensity modulated radiation therapy; RT = radiation therapy.



**Fig. 2** Rates of IMRT utilization between 2004 and 2017. *Abbreviations:* H&N = head and neck; IMRT = intensity modulated radiation therapy.



**Fig. 3** Rates of intensity modulated radiation therapy utilization in NHW and NHB cohorts in (A) early and (B) contemporary cohorts. Asterisks indicate significant differences from multivariable logistic regression. *Abbreviations:* H&N = head and neck; NHB = non-Hispanic Black; NHW = non-Hispanic White.

**Table 2** IMRT utilization in non-Hispanic White versus non-Hispanic Black patients over time.

| Cancer type | 2004 - 2010        |       |                    |       | 2011 - 2017        |       |                    |        |             |             |
|-------------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|--------|-------------|-------------|
|             | Non-Hispanic White |       | Non-Hispanic Black |       | Non-Hispanic White |       | Non-Hispanic Black |        |             |             |
|             | Number             | %     | Number             | %     | Number             | %     | Number             | %      |             |             |
| H&N         | 19,249             | 45.9% | 1938               | 40.1% | 34,001             | 64.3% | 3953               | 61.82% |             |             |
| Esophagus   | 2269               | 20.1% | 255                | 18.9% | 10,861             | 54.2% | 1038               | 51.82% |             |             |
| Stomach     | 985                | 19.3% | 138                | 21.5% | 5336               | 50.0% | 576                | 48.40% |             |             |
| Rectum      | 3417               | 14.0% | 363                | 14.9% | 12,790             | 36.8% | 1271               | 33.76% |             |             |
| Anus        | 3106               | 35.4% | 364                | 36.1% | 11,520             | 69.5% | 1296               | 66.56% |             |             |
| Brain       | 13,404             | 40.9% | 1004               | 38.4% | 30,640             | 65.9% | 2396               | 59.74% |             |             |
| Lung        | 10,287             | 11.5% | 1151               | 11.1% | 45,335             | 31.0% | 5833               | 32.81% |             |             |
| Cervix      | 1669               | 22.0% | 354                | 18.3% | 5041               | 48.7% | 1058               | 41.23% |             |             |
| Uterus      | 1805               | 25.5% | 226                | 23.5% | 5,219              | 52.6% | 811                | 46.64% |             |             |
| Prostate    | 84,172             | 69.3% | 16,457             | 67.0% | 84,204             | 74.0% | 20,171             | 73.45% |             |             |
|             |                    |       |                    |       |                    |       |                    |        | AOR* 95% CI | AOR* 95% CI |
|             |                    |       |                    |       |                    |       |                    |        |             |             |

Abbreviations: AOR = adjusted odds ratio; CI = confidence interval; H&N = head and neck; IMRT = intensity modulated radiation therapy.  
\* Adjusted for stage, age, sex, race/ethnicity, income, education, insurance status, great circle distance, treatment facility, geographic region, and use of chemotherapy, and use of surgery  
† p<0.001  
‡ p<0.05

disease site are depicted in Figure 2. Primary sites with the largest absolute change ( $\Delta$ ) in IMRT utilization during the study period were cancers of the anus ( $\Delta = 69.6\%$ ), esophagus ( $\Delta = 62.9\%$ ), stomach ( $\Delta = 59.0\%$ ), uterus ( $\Delta = 56.2\%$ ), cervix ( $\Delta = 54.1$ ), and primary brain cancer ( $\Delta = 52.3\%$ ).

When accounting for clinical and sociodemographic covariates, compared with NHW patients, NHB patients were less likely to receive IMRT in 1 of 10 disease sites (head and neck) in the 2004 to 2010 cohort, and 5 of 10 disease sites (head and neck, esophageal, rectal, cervical, and uterine) in the 2011 to 2017 cohort (Fig 3 and Table 2). Contemporary differences in IMRT utilization for Hispanic, Asian, Native American/Eskimo, and Native Hawaiian/Pacific Islander individuals were also examined and are reported in Table E1.

In the entire cohort, the distribution of primary insurance was Medicare (53.3%), private (35.1%), Medicaid (6.3%), other government (4.9%), and uninsured (4.0%). Among patients treated with IMRT, NHB patients were more often insured with Medicare (45.7% vs 54.6%) and Medicaid (11.4% vs 4.6%) compared with NHW patients. Between the early (2004-2010) and contemporary (2011-2017) cohorts, there was an increase in the percentage of NHB patients treated with IMRT insured by Medicaid (9.0%-12.7%) and a decrease in the percentage treated with IMRT who had private insurance (37.6%-32.5%). In the contemporary cohort (2011-2017) where disparities in utilization were greater, multivariable models revealed that, compared with private insurance, patients with Medicare or Medicaid were more likely to receive IMRT in 6 of 10 disease sites (head and neck, esophagus, stomach, rectum, lung, prostate) and 3 of 10 (rectum, lung, prostate), respectively (Table 3).

An analysis focused on patients with private insurance only showed that after accounting for clinical and socio-demographic factors, compared with NHW patients, NHB patients were less likely to receive IMRT in 1 of 10 disease sites (head and neck) in the early cohort and 3 of 10 disease sites (head and neck, rectal, cervical) in the contemporary cohort.

## Discussion

Inequities in access to and use of RT for Black patients with cancer have been described across a variety of disease sites including prostate, gynecologic, lung, head and neck, and breast.<sup>15</sup> Although the general RT utilization patterns and disparities are well described, the utilization of advanced radiation therapy techniques including IMRT has not been thoroughly investigated. In this retrospective database study of patients receiving definitive radiation therapy to disease sites commonly treated with IMRT, we found evidence of racial disparities in IMRT utilization, particularly affecting NHB patients, with widening gaps as IMRT utilization increased over time and despite increased awareness of the magnitude and effect of racial disparities

**Table 3 Contemporary (2011-2017) IMRT utilization by insurance relative to private insurance**

| Cancer type | Medicare |             | Medicaid |            | Uninsured |            |
|-------------|----------|-------------|----------|------------|-----------|------------|
|             | AOR      | 95% CI      | AOR      | 95% CI     | AOR       | 95% CI     |
| H&N         | 1.20     | 1.140-1.26* | 1.06     | 0.98-1.13  | 0.94      | 0.85-1.04  |
| Esophagus   | 1.09     | 1.010-1.18† | 1.06     | 0.95-1.18  | 0.95      | 0.79-1.15  |
| Stomach     | 1.15     | 1.040-1.28‡ | 1.11     | 0.94-1.30  | 1.07      | 0.83-1.36  |
| Rectum      | 1.13     | 1.055-1.20* | 1.23     | 1.13-1.37* | 1.00      | 0.89-1.13  |
| Anus        | 1.06     | 0.965-1.16  | 1.04     | 0.92-1.17  | 0.87      | 0.73-1.03  |
| Brain       | 0.74     | 0.339-1.61  | 1.30     | 0.51-3.31  | 0.83      | 0.19-3.52  |
| Lung        | 1.11     | 1.069-1.14* | 1.17     | 1.11-1.23* | 0.89      | 0.82-0.97‡ |
| Cervix      | 1.13     | 0.996-1.28  | 1.08     | 0.97-1.19  | 0.87      | 0.75-1.01  |
| Uterus      | 1.08     | 0.967-1.20  | 1.08     | 0.92-1.26  | 0.88      | 0.71-1.09  |
| Prostate    | 1.17     | 1.128-1.20* | 1.15     | 1.08-1.23* | 1.00      | 0.91-1.11  |

Abbreviations: AOR = adjusted odds ratio; CI = confidence interval; H&N = head and neck; IMRT = intensity modulated radiation therapy.  
 \*  $P < .001$ .  
 †  $P < .05$ .  
 ‡  $P < .01$ .

in oncology. Our conceptual model was constructed based on the existing literature to include clinical and demographic factors that are known to affect the use of IMRT. For example, later stage tumors often require larger or more complicated target volumes requiring IMRT to maintain low dose to organs at risk. Treatment factors including the use of surgery and chemotherapy can further alter target shape and increase toxicity profile. As different practice patterns between institutions and across geographic regions exist, these variables were also included. In an ideal world, sociodemographic factors would not drive treatment decisions while controlling for the aforementioned covariates; however, race is included in the model as a surrogate for racism given the large volume of literature suggesting that racism drives treatment inequities.

As definitive intent IMRT has been demonstrated to provide significant improvements in RT-induced toxic effects, posttreatment quality of life, and RT dose escalation, equitable utilization is critical for improving cancer outcomes in minoritized populations.<sup>4-8</sup> Of note, the aim of this study was to evaluate differences in utilization of IMRT rather than appropriateness of IMRT. Regardless of appropriateness, disparate utilization rates warrant a close examination to ensure equitable delivery of cancer treatment. Although the IMRT can be used for palliative intent treatment in specific contexts such as reirradiation or when targets are proximal to critical radiosensitive normal structures, we elected to limit the patient population for this study to include only definitive intent treatments with the goal of focusing on patients with the most likelihood of deriving long-term toxic effects and quality of life benefits from treatment with IMRT. Although NHB patients were more likely to be uninsured or underinsured, our analysis suggests that racial disparities exist even after controlling for insurance type. Nonetheless, the

question of whether insurance coverage of advanced radiation therapy modalities is equitably distributed remains unanswered. In many instances, treating patients who have private insurance using IMRT requires prior authorization, which can increase patient stress, delay treatment start, limit available physician time for direct patient care, and increase workload on departmental support staff.<sup>16,17</sup> Our analysis demonstrated that patients with Medicare and Medicaid insurance were more likely to receive IMRT for certain cancers than those with private insurance, perhaps due to challenges with prior authorization. Potentially modifiable factors warranting further investigation (eg, inequitable denial of IMRT by insurance companies) were not ascertained in our data set yet could drive differences in IMRT.<sup>18</sup> However, in our analysis limited to patients with private insurance only, the disparity in utilization persisted, suggesting insurance coverage alone does account for differential care. These findings warrant a closer examination of our health care system to better understand how this disparity has worsened over time and what solutions can address these disparities. For example, more information regarding the insurance prior authorization process and how it affects the use of IMRT are needed. The nation's history of structural racism at all points in the cancer care continuum, including insurance inclusions and prior authorization, must be acknowledged and its effects further examined to ensure equitable treatment and improved outcomes for NHB patients.<sup>19,20</sup>

Findings from this study are novel due to the focus on IMRT utilization trends instead of static evaluation and this is the first study to relate increased rates of IMRT utilization to worsening racial disparities. As IMRT rapidly becomes the most common technique for delivering radiation therapy among many disease sites, these disparities will continue to proportionally worsen if not addressed.

Removing systemic barriers to equitable access to IMRT is a critical next step in addressing these disparities and will be the focus of future projects. Future studies collecting more granular information regarding the need for the insurance prior authorization process including the frequency of approvals, denials, and appeals and how these affect the use of IMRT are needed. However, the study's limitations should be considered. First, the retrospective database design is susceptible to inherent risk of bias due to limited available data. However, our study was strengthened as the large sample size we assessed included the 10 disease sites most commonly treated with IMRT in the modern era. Second, data regarding specifics of insurance plans did not provide information regarding insurance denials, premiums, or copays that may be barriers to treatment with IMRT. Lastly, the NCDB does not contain data regarding treatment-related toxic effects or local recurrence; therefore, the direct clinical effect of lower IMRT utilization could not be assessed.

## Conclusion

Differences in utilization of IMRT may contribute to the observed racial disparities in cancer outcomes. This analysis demonstrates a concerning temporal trend of worsening disparities in utilization of IMRT in NHB patients as the overall utilization of IMRT increased in the study period. The study also found that for some cancer sites, patients with Medicare and Medicaid insurance were more likely to receive IMRT than those with private insurance, suggesting that further investigation into the equity of prior authorization and insurance denial is warranted.

## Supplementary materials

Supplementary material associated with this article can be found in the online version at [doi:10.1016/j.adro.2021.100887](https://doi.org/10.1016/j.adro.2021.100887).

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