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Disparities in fertility preservation use among adolescent and young adult women with cancer

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Abstract

Purpose—Women face multiple barriers to fertility preservation after cancer diagnosis, but few studies have examined disparities in use of these services.

Methods—Women aged 15-39 years diagnosed with cancer during 2004-2015 were identified from the North Carolina Central Cancer Registry and linked to the Society for Assisted Reproductive Technology Clinic Outcomes Reporting System. Women who cryopreserved oocytes or embryos for fertility preservation (n=96) were compared to women who received gonadotoxic treatment but did not use fertility preservation (n=7,964). Conditional logistic and log-binomial regression were used to estimate odds ratios (ORs) or prevalence ratios (PRs) and 95% confidence intervals (CIs).

Results—Few AYA women with cancer in our study (1.2%) used fertility preservation. In multivariable regression, women less likely to use fertility preservation were older at diagnosis (ages 25-29 vs. 35-39: OR = 6.27, 95% CI: 3.35, 11.73); non-Hispanic Black (vs. non-Hispanic White: PR = 0.44, 95% CI: 0.24, 0.79); parous at diagnosis (vs. nulliparous: PR = 0.24, 95% CI: 0.13, 0.45); or lived in census tracts that were non-urban (vs. urban: PR = 0.12, 95% CI: 0.04, 0.37) or of lower socioeconomic status (quintiles 1-3 vs. quintiles 4-5: PR = 0.39, 95% CI: 0.25, 0.61).

Conclusions—Women with cancer who were older, non-Hispanic Black, parous, or living in areas that were non-urban or of lower socioeconomic position were less likely to use fertility preservation.

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Implications for Cancer Survivors—Clinical and policy interventions are needed to ensure equitable access to fertility services among women facing cancer treatment-related infertility.

Keywords

Fertility Preservation; Cryopreservation; Cancer Survivors; Female

INTRODUCTION

Adolescent and young adult (AYA) women who are diagnosed with cancer face complex decisions regarding their fertility. If gonadotoxic treatments are recommended, permanent damage to the ovaries or uterus may occur, resulting in impaired reproductive function and rendering alternative methods of future family building necessary.[1-4]

Given the known harms of certain cancer treatments to reproductive health, guidelines issued since 2006 by the American Society of Clinical Oncology (ASCO) emphasize the urgency of initiating fertility-related discussions with reproductive-age patients diagnosed with cancer.[1,5,6] Yet, many barriers to fertility counseling, referral, and use of fertility preservation after cancer diagnosis exist and include institutional-, provider-, patient-, and disease-level determinants.[7-13] Undoubtedly, financial pressures present a substantial barrier to accessing fertility services. Without insurance, a cycle to cryopreserve oocytes or embryos can cost upwards of $15,000, with additional expenses for storage and later thaw and transfer to attempt pregnancy.[14-16]

Given the multilevel barriers to accessing fertility information and services after cancer diagnosis—and particularly the associated financial burden—it seems probable that sociodemographic disparities would exist in the use of fertility preservation among young women with cancer. However, to date, most studies have only assessed fertility counseling or referral; few studies in the U.S. have examined actual use of fertility preservation, with findings limited by their study populations or reliance on self-reported data.[17-19]

We aimed to examine the association between sociodemographic characteristics and fertility preservation use in a statewide sample of AYA women with cancer in North Carolina. Notably, North Carolina has no state mandate to cover fertility preservation for cancer patients at risk of iatrogenic infertility.[20] We hypothesized that women who are older at diagnosis, women of color, parous, or living in areas that are less urban or with lower socioeconomic position are less likely to use fertility preservation.

METHODS

Study population

We identified all AYA women (aged 15-39 years) diagnosed with a first primary invasive cancer in North Carolina between 2004 and 2015 from the North Carolina Central Cancer Registry (NC CCR) (n=15,998). The NC CCR is a population-based registry and gold-certified member of the North American Association of Central Cancer Registries (NAACCR), meeting standards for completeness, accuracy, and timeliness.[21] The NC CCR data includes age and date of diagnosis, cancer type, SEER summary stage, and

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first-course therapy (including any chemotherapy, radiation, surgery, or endocrine therapy and dates of administration). NC CCR data does not include data on specific treatment regimens or dosages. We defined cancer type based on the International Classification of Diseases for Oncology, Third Edition (ICD-O-3) AYA Site Recode/WHO 2008.[22] This study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill (study #21-0156). The data underlying this article cannot be shared publicly due to the privacy of individuals that participated in the study. The corresponding author can be contacted regarding sharing of a deidentified dataset with appropriate IRB approval.

Women identified from the NC CCR were probabilistically linked (Link Plus 2.0, CDC, Atlanta, GA) to the Society for Assisted Reproductive Technology Clinic Outcomes Reporting System (SART CORS) using social security number, date of birth, full name, and zip code of residence. SART CORS is a comprehensive database of assisted reproductive technology (ART) cycles performed at SART-member clinics; during the years for this analysis, SART-member clinics accounted for 90-99% of all ART cycles performed in the US and 96-100% of all ART cycles performed in NC.[23,24] Women identified in the NC CCR were also probabilistically linked to NC vital records using social security number, date of birth, and full name to define parity at diagnosis.

This analysis compared AYA women with cancer who used fertility preservation (n=96) to AYA women with cancer who received potentially gonadotoxic cancer treatment but did not use fertility preservation (n=7,964). Fertility preservation was defined as having a first ART cycle for cryopreservation of oocytes or embryos after cancer diagnosis but before receiving potentially gonadotoxic cancer treatment—including chemotherapy for any cancer; radiation for gynecologic cancers or hematologic malignancies; or surgery for gynecologic cancers. All women included in the study received potentially gonadotoxic cancer treatment. Women who initiated ART prior to a cancer diagnosis were excluded.

Sociodemographic characteristics

All individual-level characteristics were obtained from the NC CCR (race and ethnicity, marital status, and insurance) or NC birth certificates (parity). Race and ethnicity were interpreted as social constructs that act as proxies for sociopolitical and structural factors that may influence a woman’s access to fertility information and services.[25,26] These variables were categorized for analysis as Hispanic, non-Hispanic Black, non-Hispanic White, and non-Hispanic all other races. When race and ethnicity was included in adjusted analysis as a confounder for other sociodemographic predictors of fertility preservation, it was dichotomized (non-Hispanic White and all other races or ethnicity) due to small sample sizes.

Community-level characteristics were obtained through linkage of Federal Information Processing System (FIPS) codes at the census tract-level based on home address at the time of cancer diagnosis. Rural-urban commuting area (RUCA) codes were used to categorize census tracts (based on population density, urbanization, and daily commuting patterns[27]) as urban, large rural city/town, small rural town, and isolated small town rural.[28,29] Due to small sample sizes, the categories were dichotomized into urban and non-urban for analysis.[29]

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Differences in the use of fertility preservation by socioeconomic position were assessed by three indicators at the census tract-level: percent of persons aged 25 years and older with a Bachelor's degree or higher; median household income in the past 12 months; and Yost socioeconomic status (SES) index. Education and income were obtained from different American Community Survey (ACS) 5-year data releases based on year of cancer diagnosis (2005-2009 ACS for women diagnosed in 2004-2009; 2010-2014 ACS for women diagnosed in 2010-2014; and 2013-2017 ACS for women diagnosed in 2015). Tertiles of census tract-level education and income were created separately for each respective ACS data release; tertiles were used due to sparse data when the data were divided into more categories. The Yost SES index (available as quintiles at the country- and state-levels) was obtained from the NCI Social Determinants of Health by U.S. Census Tract data set.[28] This index is a time-dependent composite score constructed using seven SES-related variables, including census tract-level measures of income, poverty, education, and employment.[30] Quintiles for North Carolina were dichotomized (quintiles 1-3 and quintiles 4-5) in analysis due to small sample sizes.

Statistical analysis

Directed acyclic graphs were used to identify a priori confounders for each sociodemographic predictor of interest.[31] To evaluate the association between age at diagnosis and fertility preservation, women who used fertility preservation were matched 1:5 by cancer type to women who received potentially gonadotoxic treatment but did not use fertility preservation. Matching by cancer type for this analysis was used because of the inability to include both cancer type and age at diagnosis in a statistical model while ensuring adequate cell sizes,[32,33] given the strong association between cancer type and age in the AYA population.[34] Conditional logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) to account for the matched design.[32]

Six separate log-binomial regression models in the unmatched sample were used for all other sociodemographic characteristics (race and ethnicity, parity, rurality, and census tract-level education, income, and SES index) to estimate prevalence ratios (PRs) and 95% CIs for fertility preservation use. Each predictor was analyzed in a separate model given the differing causal pathways between each predictor variable and fertility preservation use. Parity analysis adjusted for age at diagnosis and SES index; race and ethnicity and rurality were considered confounders but were not included due to positivity violations (cell sizes of 0 women) with full adjustment,[33] and these variables had minimal influence after adjustment for age and SES. Rurality analysis adjusted for race and ethnicity. Education and income analyses adjusted for rurality; race and ethnicity were considered confounders but were not included due to positivity violations, and race and ethnicity had minimal influence on the estimated associations. Education was also considered a confounder in the income analysis, but was not included due to the moderate correlation with income. SES index analysis adjusted for race and ethnicity and rurality. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Sensitivity analyses—Our definition of fertility preservation required having an oocyte or embryo cryopreservation cycle before potentially gonadotoxic cancer treatment.

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To capture women who did not receive any known gonadotoxic treatment, had unknown gonadotoxic treatment dates, or received gonadotoxic treatment before their cryopreservation cycle (as may be the case for women who need to start therapy urgently), we expanded the definition to additionally include women who had a cryopreservation cycle within 90 days after cancer diagnosis, regardless of gonadotoxic treatment status (16 additional women).

Additionally, women without a record of a live birth during 2000-2015 were defined as nulliparous at diagnosis, which may misclassify some women who had a birth before 2000. To account for this potential exposure misclassification, we limited the parity analysis to women who were diagnosed in 2010 or later so that we captured a minimum of 10 years of potential birth outcome data before a woman's diagnosis.

RESULTS

Analyses included 8,060 AYA women with cancer: 96 women (1.2%) who used fertility preservation and 7,964 women who received potentially gonadotoxic cancer treatment but did not use fertility preservation. The fertility preservation group had a higher proportion of women diagnosed at ages 25-29 years (35% vs. 13% among the no fertility preservation group) and in more recent calendar years (56% diagnosed during 2013-2015 vs. 25% among the no fertility preservation group); diagnosed with breast cancer (55% vs. 38%); diagnosed with regional stage disease (51% vs. 37%); or who received chemotherapy (97% vs. 83%) (Table 1).

The fertility preservation group also had a greater proportion of women who were non-Hispanic White (78% vs. 64%); not married at diagnosis (60% vs. 48%); nulliparous (84% vs. 61%); with private insurance (82% vs. 50%); or living in urban areas (97% vs. 78%). And a greater proportion of the fertility preservation group lived in areas with higher education (mean of 42% of individuals 25 years and older in the census tract had a Bachelor's degree or higher vs. 27%), higher income (54% in the highest income tertile vs. 31%), and higher SES (38% in the highest Yost SES index quintile vs. 20%) (Table 2).

Unadjusted and adjusted relative measures of association from regression models are provided in Table 3. Women ages 35-39 years were least likely to use fertility preservation compared to all other age groups (e.g., ages 25-29 vs. 35-39: adjusted OR (aOR) = 6.27, 95% CI: 3.35, 11.73). Non-Hispanic Black women were less likely to use fertility preservation compared to non-Hispanic White women (PR = 0.44, 95% CI: 0.24, 0.79), as were women who were parous at diagnosis relative to nulliparous women (aPR = 0.24, 95% CI: 0.13, 0.45). This association strengthened when limiting analysis to women diagnosed in 2010 or later to account for potential misclassification of parity status due to lack of birth data prior to 2000 (aPR = 0.13, 95% CI: 0.06, 0.29).

Fertility preservation use was also less likely among women living in non-urban areas (vs. urban: aPR = 0.12, 95% CI: 0.04, 0.37); and women living in areas with lower education (e.g., tertile 1 vs. tertile 3: aPR = 0.16, 95% CI: 0.08, 0.35); lower income (e.g., tertile 1 vs. tertile 3: aPR = 0.31, 95% CI: 0.17, 0.58); or lower SES (quintiles 1-3 vs. quintiles 4-5:

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aPR = 0.39, 95% CI: 0.25, 0.61). Results remained consistent after including 16 additional women in the fertility preservation group who had a cryopreservation cycle within 90 days after cancer diagnosis (regardless of gonadotoxic treatment status).

DISCUSSION

This analysis found that AYA women diagnosed with cancer in North Carolina between 2004 and 2015 rarely used fertility preservation, and that those least likely to use fertility preservation were older at diagnosis, non-Hispanic Black, parous, living in non-urban areas, or areas with a lower socioeconomic position. This study adds to the relatively scarce evidence documenting disparities in fertility preservation use in cancer populations and, importantly, documents these disparities among a population-based, statewide sample using data obtained from medical records.

Improving access to fertility services for all women with cancer at risk of iatrogenic infertility is a stated priority of ASCO; their clinical guidelines underscore inclusivity in fertility-related discussions between patients and providers, regardless of factors like age and socioeconomic status.[5] Of note, guidelines state that all patients “should be encouraged to consider fertility preservation, even though there may be financial or insurance barriers.”[5] While it is encouraging to observe a higher prevalence of fertility preservation use in more recent years—given the importance young women diagnosed with cancer place on fertility and their documented unmet needs for fertility information and services[35-39]—our study demonstrates that use is primarily limited to only the most advantaged groups of women.

The low use of fertility preservation observed in our study (1.2% among women who received potentially gonadotoxic cancer treatment) aligns with expectations based on prior research: in a nationwide study of reproductive-age women with cervical, colorectal, lung, or breast cancer who underwent surgery and chemotherapy, 1.6% of women had administrative claims for fertility preserving procedures after diagnosis (defined as in vitro fertilization, ovarian transposition, oocyte/embryo cryopreservation, or ovarian tissue cryopreservation).[18] This low prevalence also corresponds to the 1.2% - 1.8% of births in the U.S. that resulted from assisted reproductive technologies during the study years.[24]

Our main findings align with the results of previous studies in the U.S. that reported lower rates of fertility-related discussion and referral to fertility specialists among AYAs with cancer who are older,[19,40-44] AYAs of color,[41,44,45] parous at diagnosis,[42,44] or with lower education and income.[19,45,46] Some of these previous studies were conducted at single institutions, while others included large samples of medical practices across the U.S., highlighting that these disparities are not confined to one geographic area or type of institution. Studies most consistently reported large differences in fertility discussion and referral by age at diagnosis, similar to the strong associations between age and fertility preservation use observed in our study. Such differences are likely related to a lower reproductive interest at the time of diagnosis among older AYAs, but may also be related to clinician perceptions, which should be further explored. In three studies that have examined actual use of fertility preservation among women with cancer in the U.S., mixed associations were observed by age at diagnosis,[17-19] and only one study reported disparities by race

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and ethnicity.[19] As in our study, lower use was found among women who were parous, [17,19] living in less urban areas,[18] or areas with lower income.[17] However, one study was limited to women with breast cancer from three academic hospitals;[17] the second study was limited to women with cervical, colorectal, lung, or breast cancer who were privately insured or had Medicaid and had administrative claims for fertility preservation procedures,[18] which excludes the many women who pay for fertility preservation out-of-pocket;[47] and the third study relied on self-reported survey data for fertility preservation use and key covariates.[19]

Notably, our study examined use of fertility preservation (obtained from medical records) among women with any type of cancer across an entire state without a mandate to cover such procedures.[20] In this context, the use of fertility preservation for women who are at risk of treatment-related infertility, are aware of that risk, and who desire future family building is largely influenced by their ability to access such services in the absence of insurance coverage. Though some women in our sample who used fertility preservation may have had services covered in full or in part by insurance (as some plans may still provide coverage even in a state without a mandate), more often, women likely paid costs out-of-pocket or with assistance from a private foundation.[48,49]

It has been well-documented that many women view fertility and post-cancer parenthood as major survivorship concerns, and up to half of women may want children after their cancer [39,50-54]. Yet, fertility preservation use in this population remains rare. Future research should continue to investigate the specific barriers that women with cancer face in accessing fertility treatment, including more nuanced data that captures women's reproductive interests at the time of diagnosis and the barriers faced at specific points in the fertility preservation pathway—from discussion of fertility risks, to referral to a reproductive specialist, to use of services. Such data can ensure that women who do desire future family-building are adequately supported and provided the necessary resources at the time of diagnosis.

This study's strengths include its unique linkage between a population-based state cancer registry and fertility preservation data from nearly all of the fertility clinics across North Carolina during the study years, representing 96-100% of the ART cycles performed in the state. This data linkage—using probabilistic linkage methods and highly discriminatory linking variables—ensured that we captured the majority of fertility preservation procedures that occurred among AYA women diagnosed with cancer in North Carolina (and which were documented in medical records vs. self-report only). Importantly, as a NAACCR gold-certified registry, the NC CCR provides 100% accuracy in abstraction for cancer type, sex, race, age, and county,[55] as well as complete and accurate data on cancer treatment. [56]

This study has several limitations. Our data cannot disentangle the factors contributing to the observed disparities—whether it is differences in reproductive interest at the time of cancer diagnosis (e.g., possibly driving the lower prevalence of use among older AYAs and parous women[54]); rates of receiving fertility counseling; or rates in ability to access fertility services. To ensure the most relevant group for comparison, we limited the no fertility preservation group to women who received potentially gonadotoxic cancer treatment.

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However, we lacked data on specific cancer treatment type and intensity, so we cannot determine the level of risk for gonadal injury, given that the risk varies by chemotherapeutic agent and radiation dosage received.[57,58] We also lacked data on women who may have used ovarian tissue cryopreservation as a method of fertility preservation, though this is likely to be minimal given that it was an experimental procedure until 2019 (four years after the end of our study), and is still considered technically challenging and has relatively limited—but growing—use.[59]

Even with a statewide sample spanning 12 years of cancer diagnoses, fewer than 100 women used fertility preservation, limiting our ability to analyze all groups of interest. For example, race and ethnicity was grouped into four categories for its primary analysis, and further dichotomized when included as a confounder. These combined racial and ethnic groups may be heterogenous, for instance, in their lived experiences of racism in the healthcare system and their level of accessibility to fertility information and services.[26] Our data does not capture women who were diagnosed with cancer in North Carolina but used fertility preservation outside of the state or at a non-SART-member fertility clinic, though SART CORS includes the majority of fertility clinics in the state.[23] Change in state residence may also result in misclassification of parity status if a woman gave birth outside of North Carolina. And because data are limited to one state without an insurance mandate for fertility preservation coverage in cases of iatrogenic infertility, our findings may not generalize to other states with varying fertility treatment coverage.

Conclusions

Previous studies have documented the sociodemographic disparities in fertility-related discussion and referral to fertility specialists among AYAs diagnosed with cancer. Our study adds novel, statewide data demonstrating that these disparities persist in fertility treatment: AYAs with cancer who were older, non-Hispanic Black, parous, living in non-urban areas, or areas with lower socioeconomic position were less likely to use fertility preservation. With additional confirmation of our findings, state or federal legislation that mandates fertility preservation coverage for iatrogenic infertility would broaden access to fertility services. All women, regardless of their sociodemographic characteristics, should be granted equitable access to pursue fertility preservation if desired.

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Table 1.

Cancer characteristics among AYA women with cancer in North Carolina, 2004-2015, by use of oocyte or embryo cryopreservation for fertility preservation (n=8,060)

	Used fertility preservation, n=96		Received gonadotoxic treatment but no fertility preservation,[a] n=7964	
	n	%	n	%
Mean age at diagnosis (SD)	29.8	(5.2)	32.7	(5.8)
Median age at diagnosis (iQr)	30.0	(6.5)	34.0	(7.0)
Age at diagnosis, years				
15-24	12	12.5	890	11.2
25-29	34	35.4	1071	13.4
30-34	30	31.3	2129	26.7
35-39	20	20.8	3874	48.6
Year of cancer diagnosis				
2004-2009	18	18.7	4050	50.9
2010-2012	24	25.0	1955	24.5
2013-2015	54	56.3	1959	24.6
Cancer type *(invasive only)*				
Breast	53	55.2	3013	37.8
Gynecologic[b]	<11	<11.5	2103	26.4
Hematologic	21	21.9	1309	16.4
Hodgkin lymphoma	14	14.6	553	6.9
Non-Hodgkin lymphoma, leukemia, or myeloma[b]	<11	<11.5	756	9.5
Other	18	18.8	1539	19.3
SEER summary stage				
Localized	37	38.5	3041	38.2
Regional	49	51.0	2978	37.4
Distant[b]	<11	<11.5	1828	23.0
Unstaged/unknown/unspecified[b]	<11	<11.5	117	1.5
First-course chemotherapy	93	96.9	6628	83.2

Abbreviations: AYA, adolescent and young adult; IQR, interquartile range; SD, standard deviation.

[a]Gonadotoxic treatment is defined as chemotherapy for any cancer; radiation for gynecologic cancers and hematologic malignancies; or surgery for gynecologic cancers. The comparator group excludes women who initiated assisted reproductive technology prior to cancer diagnosis (n=29).

[b]Exact number not reported because the North Carolina Central Cancer Registry requires cell sizes <11 to be suppressed.

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Table 2.

Sociodemographic characteristics among AYA women with cancer in North Carolina, 2004-2015, by use of oocyte or embryo cryopreservation for fertility preservation (n=8,060)

	Used fertility preservation, n=96		Received gonadotoxic treatment but no fertility preservation,[a] n=7964	
	n	%[b]	n	%[b]
Race and ethnicity				
Hispanic[c]	<11	<11.5	513	6.5
Non-Hispanic Black	13	13.5	1993	25.5
Non-Hispanic White	75	78.1	5005	63.9
Non-Hispanic all other races[c,d]	<11	<11.5	316	4.0
Missing	0	0.0	137	1.7
Marital status at diagnosis				
Never married or widowed, divorced, or separated	43	59.7	3195	47.9
Married or domestic partner	29	40.3	3469	52.1
Missing	24	25.0	1300	16.3
Parity at diagnosis				
Nulliparous[e]	81	84.4	4889	61.4
Parous	15	15.6	3075	38.6
Insurance status at diagnosis				
Private	78	82.1	3891	50.4
Medicaid[c]	<11	<11.5	1592	20.6
Other government[c,f]	<11	<11.5	474	6.1
Insurance, not otherwise specified[c]	<11	<11.5	992	12.9
Not insured[c]	<11	<11.5	769	10.0
Missing	1	1.0	246	3.1
Rurality				
Urban	90	96.8	6184	77.9
Large rural city/town[c]	<11	<11.5	1198	15.1
Small rural town[c]	<11	<11.5	318	4.0
Isolated small town rural[c]	<11	<11.5	234	2.9
Missing	3	3.1	30	0.4
Education (census tract): proportion of persons age 25 years and older with ≥ Bachelor's degree,[g] Mean (SD)	0.42	(0.19)	0.27	(0.18)
Tertile 1 – Tertile 2 *(lowest)*[h]	34	36.6	5431	69.3
Tertile 3 *(highest)*	59	63.4	2405	30.7
Missing	3	3.1	128	1.6
Income (census tract): median (IQR) household income in past 12 months[i]	$55,586	($21,884)	$48,227	($22,979)

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	Used fertility preservation, n=96		Received gonadotoxic treatment but no fertility preservation,[a] n=7964	
	n	%[b]	n	%[b]
Tertile 1 *(lowest)*	13	14.0	2815	35.9
Tertile 2	30	32.3	2609	33.3
Tertile 3 *(highest)*	50	53.8	2407	30.7
Missing	3	3.1	133	1.7
Yost SES index [j]				
Quintile 1 *(lowest)*[c]	<11	<11.5	1613	20.8
Quintile 2[c]	<11	<11.5	1472	19.0
Quintile 3	18	19.6	1551	20.0
Quintile 4	30	32.6	1591	20.5
Quintile 5 *(highest)*	35	38.0	1535	19.8
Missing	4	4.2	202	2.5

Abbreviations: AYA, adolescent and young adult; IQR, interquartile range; SD, standard deviation.

[a]Gonadotoxic treatment is defined as chemotherapy for any cancer; radiation for gynecologic cancers and hematologic malignancies; or surgery for gynecologic cancers. The comparator group excludes women who initiated assisted reproductive technology prior to cancer diagnosis (n=29).

[b]Percentages exclude missing values.

[c]Exact number not reported because the North Carolina Central Cancer Registry requires cell sizes <11 to be suppressed.

[d]Non-Hispanic all other races includes American Indian, Aleutian, or Eskimo (n=68); Asian or Pacific Islander (n=192); and other race, not otherwise specified (n=60).

[e]Assumes that women without a record of a live birth in North Carolina during 2000-2015 were nulliparous at diagnosis.

[f]Other government includes Medicare, TRICARE, Military, Veterans Affairs, and Indian/Public Health Service.

[g]Tertile cutpoints for the proportion of a census tract with a Bachelor's degree or higher were: 0.15 and 0.30 for AYA women diagnosed with invasive cancer in 2004-2009 (ACS 2005-2009 5-year data release); 0.17 and 0.33 for AYA women diagnosed with invasive cancer in 2010-2014 (ACS 2010-2014 5-year data release); and 0.19 and 0.36 for AYA women diagnosed with invasive cancer in 2015 (ACS 2013-2017 5-year data release).

[h]Categories are combined because the North Carolina Central Cancer Registry requires cell sizes <11 to be suppressed.

[i]Tertile cutpoints for median household income were $44,590 and $58,926 for AYA women diagnosed with invasive cancer in 2004-2009 (ACS 2005-2009 5-year data release); $40,626 and $54,594 for AYA women diagnosed with invasive cancer in 2010-2014 (ACS 2010-2014 5-year data release); and $41,576 and $56,622 for AYA women diagnosed with invasive cancer in 2015 (ACS 2013-2017 5-year data release). All amounts are in 2015 inflation-adjusted dollars.

[j]Yost SES index: a time-dependent composite score constructed from the following census tract variables: median household income, median house value, median rent, percent below 150% of poverty line, education index, percent working class, and percent unemployed.

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Table 3.

Associations between sociodemographic characteristics and fertility preservation use among AYA women with cancer in North Carolina, 2004-2015[a]

Model 1: age at diagnosis	**n, FP**	**n, no FP**	**Unadjusted OR (95% CI)**	**Adjusted OR[b] (95% CI)**
15-24 years	96	480	2.61 (1.27, 5.36)	3.17 (1.31, 7.70)
25-29 years			6.15 (3.53, 10.73)	6.27 (3.35, 11.73)
30-34 years			2.73 (1.55, 4.82)	2.53 (1.39, 4.62)
35-39 years			1.	1.
Model 2: race and ethnicity	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR (95% CI)**
Hispanic	96	7827	0.52 (0.19, 1.43)	No adjustment set
Non-Hispanic Black			0.44 (0.24, 0.79)	
Non-Hispanic all other races			0.85 (0.31, 2.30)	
Non-Hispanic White			1.	
Model 3: parity at diagnosis	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR[c] (95% CI)**
Nulliparous	92	7762	1.	1.
Parous			0.30 (0.17, 0.52)	0.24 (0.13, 0.45)
Model 4: rurality	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR[d] (95% CI)**
Non-urban	93	7801	0.12 (0.04, 0.38)	0.12 (0.04, 0.37)
Urban			1.	1.
Model 5: education (census tract: % with ≥ Bachelor's degree)	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR[e] (95% CI)**
Tertile 1 *(lowest)*	93	7836	0.12 (0.06, 0.25)	0.16 (0.08, 0.35)
Tertile 2			0.41 (0.26, 0.64)	0.47 (0.29, 0.74)
Tertile 3 *(highest)*			1.	1.
Model 6: income (census tract: median household income)	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR[e] (95% CI)**
Tertile 1 *(lowest)*	93	7831	0.23 (0.12, 0.41)	0.31 (0.17, 0.58)
Tertile 2			0.56 (0.36, 0.88)	0.64 (0.41, 1.01)
Tertile 3 *(highest)*			1.	1.
Model 7: Yost SES index (census tract)	**n, FP**	**n, no FP**	**Unadjusted PR (95% CI)**	**Adjusted PR[f] (95% CI)**
Quintile 1 – Quintile 3 *(lowest)*	92	7632	0.28 (0.18, 0.44)	0.39 (0.25, 0.61)
Quintile 4 – Quintile 5 *(highest)*			1.	1.

Abbreviations: CI, confidence interval; FP, fertility preservation; PR, prevalence ratio; SES, socioeconomic status.

[a]Adjusted estimates exclude women who were missing data for any model covariates. Sample sizes by FP use reflect the number of women included in the adjusted model.

[b]Women who used FP were matched 1:5 to women who did not use FP on cancer type.

[c]Adjusted for age at diagnosis and Yost SES index.

[d] Adjusted for race and ethnicity.

[e] Adjusted for rurality.

[f] Adjusted for race and ethnicity and rurality.

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