Treatment Inequity: Examining the Influence of Non-Hispanic Black Race and Ethnicity on Pancreatic Cancer Care and Survival in Wisconsin

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ABSTRACT

Introduction: We investigated race and ethnicity-based disparities in first course treatment and overall survival among Wisconsin pancreatic cancer patients.

Methods: We identified adults diagnosed with pancreatic adenocarcinoma in the Wisconsin Cancer Reporting System from 2004 through 2017. We assessed race and ethnicity-based disparities in first course of treatment via adjusted logistic regression and overall survival via 4 incremental Cox proportional hazards regression models.

Results: The study included 8,490 patients: 91.3% (n = 7,755) non-Hispanic White; 5.1% (n = 437) non-Hispanic Black, 1.8% (n = 151) Hispanic, 0.6% Native American (n = 53), and 0.6% Asian (n = 51) race and ethnicities. Non-Hispanic Black patients had lower odds of treatment than non-Hispanic White patients for full patient (OR, 0.52; 95% CI, 0.41-0.65) and Medicare cohorts (OR, 0.40; 95% CI, 0.29-0.55). Non-Hispanic Black patients had lower odds of receiving surgery than non-Hispanic White patients (full cohort OR, 0.67 [95% CI, 0.48-0.92]; Medicare cohort OR, 0.57 [95% CI, 0.34-0.93]). Non-Hispanic Black patients experienced worse survival than non-Hispanic White patients in the first 2 incremental Cox proportional hazard regression models (model II HR, 1.18; 95% CI, 1.06-1.31). After adding insurance and treatment course, non-Hispanic Black and non-Hispanic White patients experienced similar survival (HR, 0.98; 95% CI, 0.88-1.09).

Conclusion: Non-Hispanic Black patients were almost 50% less likely to receive any treatment and 33% less likely to receive surgery than non-Hispanic White patients. After including treatment course, non-Hispanic Black and non-Hispanic White patient survival was similar. Increasing non-Hispanic Black patient treatment rates by addressing structural factors affecting treatment availability and employing culturally humble approaches to treatment discussions may mitigate these disparities.

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BACKGROUND

Pancreatic ductal adenocarcinoma (PDAC) remains one of the deadliest cancers in the United States, with a 5-year survival rate of 9%.[1] It accounts for an estimated 3% of new cancer cases nationally for both sexes yet is responsible for an estimated 8% of cancer deaths in both sexes.[1] PDAC incidence and death rates are both increasing[2] and, in the absence of early detection screening, clear symptoms of early-stage disease, and curative treatments for regional and distant disease, these trends are likely to persist.

Siegal et al note that 5-year PDAC survival rates are similar for Black and White patients.[1] However, disparities in PDAC overall survival, treatment, and stage at diagnosis between Black and White patients are well documented. Studies have shown that non-Hispanic Black patients are less likely than non-Hispanic White patients to receive an oncology consultation of any kind.[3,4] Additionally, chemotherapy receipt is lower among non-Hispanic Black patients than non-Hispanic White patients, for both regional and distant disease and when paired with surgical resection.[5-8] Surgical resection—the only curative treatment for pancreatic cancer—is offered to, accepted by, and performed on non-Hispanic Black patients at lower rates than their non-Hispanic White counterparts.[5,6,8-13]

An estimated 950 Wisconsinites died from PDAC in 2020, making it the second most common cancer-related cause of death in the state.[1] Wisconsin ranks in the top quarter of states for pancreatic cancer mortality.[1] Additionally, Wisconsin has the worst death rate ratio—1.30 (95% CI, 1.18-1.42)—between non-

Hispanic Black and non-Hispanic White cancer patients of all states.[1] This death rate ratio climbed to 1.78 (95% CI, 1.56-2.02) between non-Hispanic Black and non-Hispanic White patients under age 65.

We investigated race- and ethnicity-based disparities in PDAC treatment and survival among Wisconsin patients. We also investigated the relationship between race and ethnicity and other social factors that impact cancer outcomes, including insurance status, rurality, and treatment. Our 2 primary outcomes of interest were (1) whether race- and ethnicity-based disparities existed in terms of receipt of any treatment versus no treatment, and (2) for those patients who received any treatment, whether disparities existed in terms of surgical receipt—either with or without chemoradiation—versus definitive chemoradiation. Secondary to these treatment outcomes, we examined whether race- and ethnicity-based survival disparities existed amongst Wisconsin PDAC patients.

METHODS

This study was approved by the University of Wisconsin – Madison Institutional Review Board.

Patient Cohort

Data were provided by the Wisconsin Cancer Reporting System (WCRS), which requires facilities to record the first course of treatment after diagnosis for each cancer. Patients diagnosed with PDAC between January 1, 2004, and December 31, 2017, were selected for analysis. We defined PDAC using the appropriate ICD-0-3 codes for site of origin (C25.0, C25.1, C25.2, C25.3, C25.7, C25.8, or C25.9) and histology (8140 and 8500). Patients with missing sex, rurality, first course treatment, or survival time were excluded from analysis. The 1.1% of patients who were missing data were spread across race and ethnicities, and we assumed missing data would not alter our findings.

Individual-Level Variables

We categorized first course treatment 3 ways to utilize in different analyses. First, we created "any treatment," a binary variable differentiating between patients with a documented first course treatment of chemotherapy, radiation, or surgery—in combination or individually—versus patients with no documented first course treatment.[14] Second, we created "treatment type," a binary variable differentiating between patients who had a documented first course treatment of chemotherapy or radiation ("definitive chemoradiation") versus surgery, alone or in combination with chemotherapy and/or radiation. Finally, we created "treatment course" to categorize patients based on those who had no documented first course treatment, those who had documented chemotherapy and/or radiation as the first course of treatment, and those who had surgery with or without chemotherapy and/or radiation as their first course of treatment.

The race/ethnicity variable was consolidated to include Non-Hispanic White, Non-Hispanic Black, Native American, Hispanic, Asian, and patients with unknown or Pacific Islander race and ethnicity (Other). We further consolidated the Native American, Asian, and Other race and ethnicity categories in some tables to preserve patient confidentiality when few patients were present for specific categories.

Insurance categories were consolidated such that 1 "Private" insurance category included patients with managed care, health maintenance organization, preferred provider organization, and fee-for-service insurance. Patients with Tricare, Veterans Administration (VA), or military insurance also were categorized together. Patients with Indian Health insurance were included in the "Insurance, NOS" category, and patients with unknown insurance status, no insurance, or self-pay were categorized together.

Patient rurality status was assigned at the county level using the US Department of Agriculture's 2013 Rural-Urban Continuum codes (RUCC).

County-Level Variables

Wisconsin county-level education status and median household income were accessed from Social Explorer (SocialExplorer.com, accessed May 10, 2021). American Community Survey 5-year estimates for 2009-2013 were used since these years represented the midpoint of the WCRS registry data. The percent population of individuals 25 years and older with a high school degree or equivalent was calculated for each county. The counties were ranked and assigned a quartile based on that percent. The counties also were ranked by their median income and assigned a quartile. These county-level variables were assigned to each case based on the case's county of residence at diagnosis.

Statistical Analysis

We summarized patient characteristics across the variables of interest and potential confounders by race and ethnicity categories. Categorical variables were summarized by number and percentage, and continuous variables were summarized by mean and 95% confidence interval. We used a chi-square test to evaluate differences between the categorical and continuous variables by race and ethnicity.

We conducted multivariable logistic regression to evaluate the odds ratios (OR) of any versus no treatment for first course treatment (Any Treatment model) and definitive chemoradiation versus surgery (Type of Treatment model) for those patients who had any treatment documented for their first course of treatment. We analyzed a basic model, which included patient age, sex, rurality, and race and ethnicity, and a comprehensive model, which included basic model variables and SEER (Surveillance, Epidemiology, and End Results) stage at diagnosis and insurance for both the Any Treatment and Type of Treatment models. We incorporated county-level education attainment and median

Table 1. Characteristics of Pancreatic Cancer Patients by Race and Ethnicity, Wisconsin Cancer Reporting System, 2004-2017

Variable	Non-Hispanic White (n=7,755) Count	% of Total	Non-Hispanic Black (n=437) Count	% of Total	Native American (n=53) Count	% of Total	Hispanic (n=141) Count	% of Total	Asian (n=51) Count	% of Total	Other (n=53) Count	% of Total	Total (n=8,490) Count	% of Total
Age (years)														
Mean and SD	69.4	11.3	64.6	11.2	63.3	11.2	65.3	12.3	64.6	11.0	73.5	12.5	69.1	11.4
Sex														
Male	4113	53.0%	216	49.4%	28	52.8%	91	64.5%	20	39.2%	27	50.9%	4495	52.9%
Female	3642	47.0%	221	50.6%	24	45.3%	50	35.5%	31	60.8%	26	49.1%	3994	47.0%
SEER stage														
Localized	741	9.6%	54	12.4%			15	10.6%	6	11.8%			819	9.6%
Regional	2735	35.3%	147	33.6%	23	43.4%	39	27.7%	17	33.3%	17	32.1%	2978	35.1%
Distant	4115	53.1%	232	53.1%	28	52.8%	84	59.6%	28	54.9%	20	37.7%	4507	53.1%
Unstaged	147	1.9%											169	2.0%
Rurality (RUCC)														
Mean and SD	3.1	2.1	1.3	0.7	4.9	2.7	1.7	1.1	2.4	1.5	3.4	2.2	3.0	2.1
Treatment course														
No treatment	2221	28.6%	156	35.7%	16	30.2%	44	31.2%	19	37.3%	30	56.6%	2486	29.3%
Definitive chemo-radiation	3877	50.0%	206	47.1%	26	49.1%	63	44.7%	20	39.2%	8	15.1%	4200	49.5%
Surgery, with or without definitive chemoradiation	1599	20.6%	72	16.5%	11	20.8%	32	22.7%	11	21.6%	9	17.0%	1734	20.4%
Insurance														
Private	1755	22.6%	72	16.5%	13	24.5%	27	19.1%	15	29.4%	0	0.0%	1882	22.2%
Medicare	4699	60.6%	207	47.4%	24	45.3%	76	53.9%	20	39.2%	13	24.5%	5039	59.4%
Medicaid	257	3.3%	92	21.1%	7	13.2%	16	11.3%	9	17.6%	0	0.0%	381	4.5%
VA/Tricare/Military	233	3.0%	21	4.8%									264	3.1%
Insurance, NOS	483	6.2%	20	4.6%	6	11.3%							520	6.1%
Self-pay/not insured/unknown	328	4.2%	25	5.7%			12	8.5%			32	60.4%	404	4.8%
Overall survival (months)														
Mean and SD	9.6	12.6	8.6	9.6	10.7	14.2	8.3	10.2	8.3	10.2	3.5	4.3	9.5	12.4

Abbreviations: SEER, Surveillance, Epidemiology, and End Results; RUCC, Rural-Urban Continuum Codes; VA, Veterans Administration.

household income into these models to assess whether these social factors impacted the results. We conducted this analysis on the full patient cohort, including testing for an interaction between race and ethnicity and insurance, the subset of Medicare patients, and the subset of Medicare patients with supplemental insurance. The latter 2 cohorts were analyzed to minimize insurance as a potential effect modifier.

We also conducted a survival analysis with multivariate Cox proportional hazards regression to assess risk of death. Here, we completed stepwise analysis starting with a basic model that included age, sex, rurality, and race and ethnicity. We repeated the analysis 3 times as we individually added insurance, SEER stage at diagnosis, and treatment course to the regression. We incorporated county-level education attainment and median household income into these models to assess whether these social factors affected the results. We again repeated this series of analyses on the full patient cohort, the subset of Medicare patients, and the subset of Medicare patients with supplemental insurance.

RESULTS
Patient Characteristics
We identified 8,490 patients with PDAC, of which 437 were of non-Hispanic Black race/ethnicity and 7,755 were of non-Hispanic White race/ethnicity. Table 1 illustrates the distribution of patient characteristics by race and ethnicity. Non-Hispanic Black patients were diagnosed at a younger mean age (64.6 years; 95% CI, 63.6-65.7) compared to non-Hispanic White patients (69.4; 95% CI, 69.1-69.6) ($P < 0.001$). Non-Hispanic Black patients had a higher percentage of localized disease diagnoses than non-Hispanic White patients (12.4% vs 9.6%, respectively), though 53.1% of both groups were diagnosed with distant disease ($P = 0.09$). Non-Hispanic Black patients tended to be from metropolitan counties with a mean RUCC code of 1.3, while non-Hispanic White patients had a mean RUCC code of 3.1 ($P < 0.001$). A higher percentage of non-Hispanic Black patients had no documented first course of treatment (35.7%) compared to non-Hispanic White patients (28.6%) ($P = 0.01$). Fewer non-

Table 2. Sequential Models of Adjusted Cox Proportional Hazards Regression for Overall Survival[a]

All Patients	Model I			Model II			Model III			Model IV		
Variable	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P* value
Age												
Continuous	1.03	1.02–1.03	<0.001	1.03	1.03–1.03	<0.001	1.03	1.03–1.03	<0.001	1.01	1.01–1.01	<0.001
Sex												
Male	ref			ref			ref			ref		
Female	0.97	0.93–1.02	0.223	0.98	0.94–1.03	0.405	0.99	0.94–1.03	0.532	0.94	0.90–0.99	0.015
Race/ethnicity												
Non-Hispanic White	ref			ref			ref			ref		
Non-Hispanic Black	1.12	1.01–1.24	0.038	1.18	1.06–1.31	0.002	1.11	0.99–1.23	0.065	0.98	0.88–1.09	0.706
Native American	1.09	0.83–1.45	0.528	1.14	0.86–1.51	0.352	1.10	0.83–1.46	0.496	1.10	0.83–1.45	0.527
Asian	1.02	0.76–1.39	0.881	0.97	0.71–1.31	0.834	0.91	0.67–1.23	0.525	0.66	0.48–0.90	0.008
Hispanic	1.03	0.86–1.24	0.713	1.01	0.78–1.49	0.887	0.98	0.82–1.17	0.830	0.95	0.79–1.14	0.575
Other	1.20	0.87–1.66	0.270	1.08	0.78–1.49	0.638	0.87	0.62–1.21	0.408	0.57	0.41–0.80	0.001
Rurality (RUCC)												
Continuous	0.99	0.98–1.00	0.171	0.99	0.98–1.00	0.249	0.99	0.98–1.00	0.154	1.00	0.99–1.01	0.773
SEER stage												
Localized				ref			ref			ref		
Regional				1.05	0.97–1.15	0.225	1.06	0.97–1.16	0.193	1.31	1.20–1.43	<0.001
Distant				2.72	2.50–2.96	<0.001	2.73	2.51–2.97	<0.001	2.48	2.28–2.71	<0.001
Unstaged				2.20	1.85–2.62	<0.001	2.09	1.75–2.49	<0.001	1.32	1.10–1.57	0.002
Insurance												
Private							ref			ref		
Medicare							1.04	0.97–1.12	0.297	1.07	1.00–1.15	0.052
Medicaid							1.41	1.25–1.59	<0.001	1.25	1.11–1.41	<0.001
Tricare/VA/Military							1.16	1.01–1.34	0.036	1.09	0.94–1.25	0.250
Insurance, NOS							1.08	0.98–1.20	0.133	1.01	0.91–1.12	0.858
Not insured, self pay, unknown							1.49	1.32–1.69	<0.001	1.16	1.02–1.31	0.020
Treatment course												
No treatment										ref		
Definitive chemoradiation										0.33	0.31–0.34	<0.001
Surgery, with or without neoadjuvant and/or adjuvant treatment										0.16	0.15–0.18	<0.001
Unknown										0.47	0.36–0.61	<0.001

[a]Model I included age, sex, race/ethnicity, and rurality. Model II included age, sex, race/ethnicity, rurality, and SEER Stage. Model III included age, sex, race/ethnicity, rurality, SEER stage and insurance. Model IV included age, sex, race/ethnicity, rurality, SEER stage, insurance, and treatment course. 91 patients were excluded for missing survival time, sex, and/or rurality. County-level education status and median household income were added to each model, and the results remained consistent with those shown here.

Abbreviations: HR, hazard ratio; SEER, Surveillance, Epidemiology, and End Results; RUCC, Rural-Urban Continuum Codes; VA, Veterans Administration.

Hispanic Black patients (16.5%) had surgery included in their first course of treatment than non-Hispanic White patients (20.6%) (*P*=0.01). A lower percentage of non-Hispanic Black patients had private (16.5%) and Medicare (47.4%) insurance compared to non-Hispanic White patients (22.6% and 60.6%, respectively). A higher percentage of non-Hispanic Black patients had Medicaid insurance (21.1%) than non-Hispanic White patients (3.3%) (*P*<0.001).
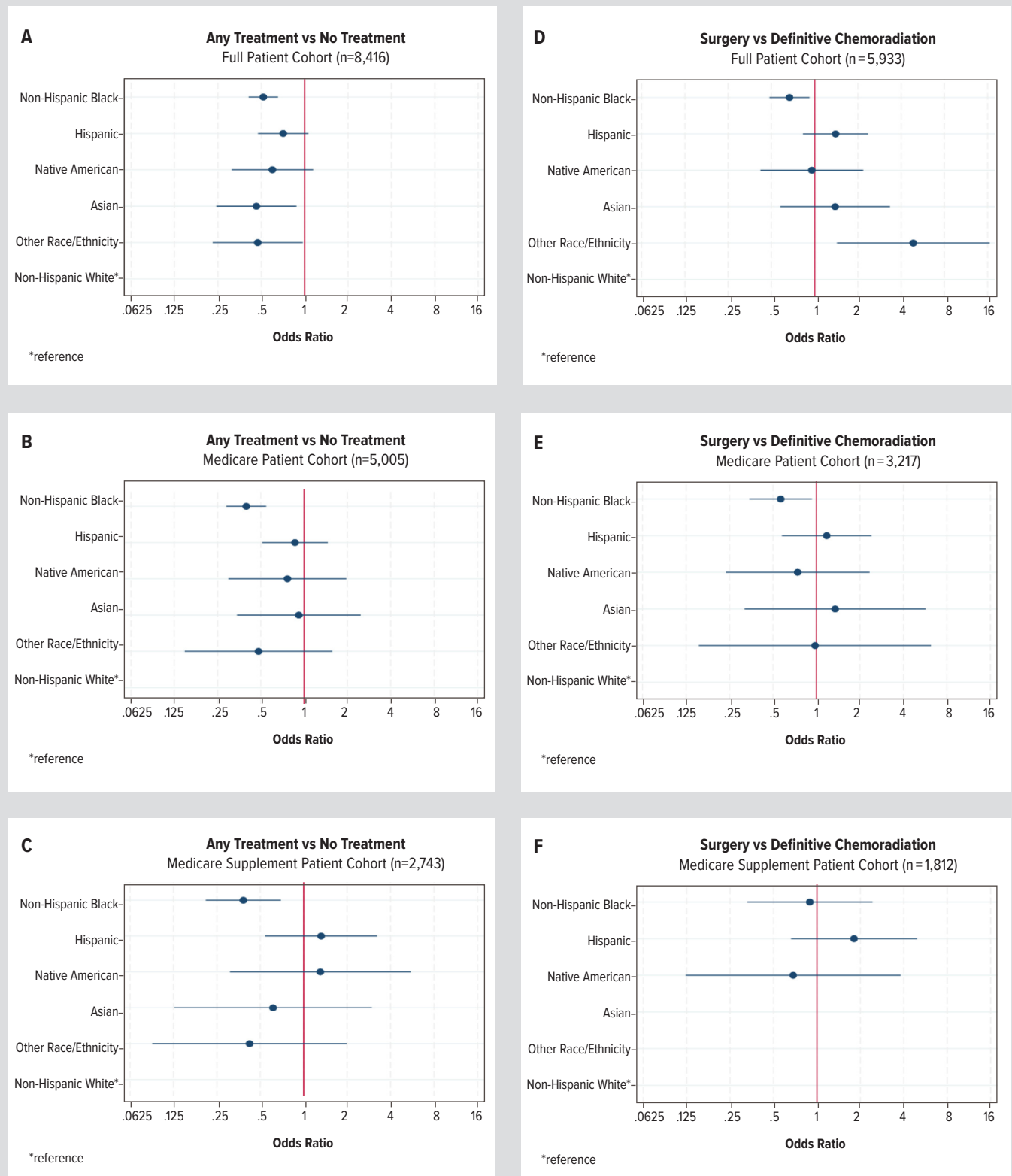
Any vs No First Course of Treatment

Non-Hispanic Black patients had a significantly lower OR of receiving any versus no treatment compared to non-Hispanic White patients (OR, 0.52; 95% CI, 0.41-0.65) when controlling for age, sex, race/ethnicity, rurality, SEER stage, and insurance (Figure A). This remained consistent after adding county-level education status and median household income to the analysis (OR, 0.58; 95% CI, 0.45-0.74). This was also true for Asian patients (OR, 0.47; 95% CI, 0.38-0.59) and patients with a race/ethnicity categorized as Other (OR, 0.48; 95% CI, 0.232-0.98). We also found that patients with Medicare (OR, 0.79; 95% CI, 0.65-0.95), Medicaid (OR, 0.40; 95% CI, 0.29-0.53), TRICARE/Military/VA (OR, 0.44; 95% CI, 0.32-0.61), Insurance, NOS (OR, 0.66; 95% CI, 0.50-0.88), and Self Pay/Not Insured/Unknown (OR, 0.27; 95% CI, 0.20-0.36) insurances all demonstrated significantly lower ORs for receiving treatment compared to patients with private insurance.

Non-Hispanic Black Medicare patients had an OR of receiving any versus no treatment of 0.32 (95% CI, 0.23-0.45), while non-Hispanic White Medicare patients had an OR of 0.78 (95% CI, 0.64-0.94) compared to non-Hispanic White pri-

Figure. Adjusted Odds Ratios (OR) of Intended First Course Treatment by Race and Ethnicity and Insurance Subsets

A
Any Treatment vs No Treatment
Full Patient Cohort (n=8,416)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

D
Surgery vs Definitive Chemoradiation
Full Patient Cohort (n = 5,933)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

B
Any Treatment vs No Treatment
Medicare Patient Cohort (n=5,005)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

E
Surgery vs Definitive Chemoradiation
Medicare Patient Cohort (n = 3,217)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

C
Any Treatment vs No Treatment
Medicare Supplement Patient Cohort (n=2,743)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

F
Surgery vs Definitive Chemoradiation
Medicare Supplement Patient Cohort (n = 1,812)

Non-Hispanic Black
Hispanic
Native American
Asian
Other Race/Ethnicity
Non-Hispanic White*

Odds Ratio
.0625 .125 .25 .5 1 2 4 8 16

*reference

ORs for patients of Asian and Other race/ethnicity were omitted from (F) for low sample size (n≤5). Full patient cohort models (A and D) are adjusted for age, sex, race, ethnicty, rurality, SEER stage, and insurance. Medicare patient cohort models (B and E) and Medicare Supplement patient cohort models (C and F) are adjusted for age, sex, race/ethnicity, rurality, and SEER stage. Odds ratios are shown on a log scale.

Abbreviation: SEER, Surveillance, Epidemiology, and End Results.

Table 3. Sequential Models of Adjusted Cox Proportional Hazards Regression for the Subset of Medicare Patients for Overall Survival[a]

Medicare Patients	Model I			Model II			Model IV		
Variable	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P value*
Age									
Continuous	1.03	1.03–1.04	<0.001	1.03	1.03–1.04	<0.001	1.01	1.01–1.02	<0.001
Sex									
Male	ref			ref			ref		
Female	1.00	0.94–1.06	0.994	1.03	0.97–1.09	0.363	0.96	0.91–1.02	0.186
Race/ethnicity									
Non-Hispanic White	ref			ref			ref		
Non-Hispanic Black	1.12	0.97–1.30	0.128	1.18	1.02–1.37	0.029	0.93	0.80–1.08	0.351
Native American	0.88	0.58–1.34	0.550	1.04	0.68–1.59	0.848	1.12	0.73–1.70	0.601
Asian	1.05	0.67–1.65	0.820	0.90	0.57–1.41	0.641	0.82	0.52–1.29	0.395
Hispanic	1.10	0.87–1.39	0.442	1.11	0.87–1.40	0.403	1.15	0.91–1.46	0.243
Other	0.90	0.47–1.74	0.760	1.70	0.57–2.11	0.779	1.00	0.52–1.92	0.998
Rurality (RUCC)									
Continuous	0.99	0.97–1.00	0.104	0.99	0.98–1.00	0.122	0.99	0.98–1.01	0.375
SEER stage									
Localized				ref			ref		
Regional				1.00	0.91–1.11	0.935	1.25	1.13–1.39	<0.001
Distant				2.50	2.26–2.76	<0.001	2.32	2.09–2.56	<0.001
Unstaged				1.91	1.53–2.38	<0.001	1.32	1.06–1.64	0.014
Treatment course									
No treatment							ref		
Definitive chemoradiation							0.32	0.30–0.35	<0.001
Surgery, with or without neoadjuvant and/or adjuvant treatment							0.16	0.14–0.18	<0.001
Unknown							0.49	0.34–0.69	0.001

[a]Model I included age, sex, race/ethnicity, and rurality. Model II included age, sex, race/ethnicity, rurality, and SEER stage. Model III was not completed since all patients had Medicare insurance. Model IV included age, sex, race/ethnicity, rurality, SEER stage, and treatment course. Thirty-three patients were excluded for missing survival time, sex, and/or rurality. County-level education status and median household income were added to each model, and the results remained consistent with those shown here.

Abbreviations: HR, hazard ratio; SEER, Surveillance, Epidemiology, and End Results; RUCC, Rural-Urban Continuum codes; VA, Veterans Administration.

vate insurance patients. Likewise, non-Hispanic Black Medicaid patients had an OR of 0.20 (95% CI, 0.12-0.33) and non-Hispanic White Medicaid patients had an OR of 0.37 (95% CI, 0.26-0.52) compared to non-Hispanic White private insurance patients. Privately insured and uninsured non-Hispanic Black patients had similar ORs of treatment as their non-Hispanic White counterparts, respectively.

We repeated this analysis on the 5,039 patients with Medicare insurance to minimize insurance as a potential mediating factor to treatment. We found that non-Hispanic Black Medicare patients had a significantly lower OR of any versus no treatment compared to non-Hispanic White Medicare patients (OR, 0.40; 95% CI, 0.29-0.55) (Figure B). Again, this result remained consistent when education status and median household income were added to the analysis (OR, 0.44; 95% CI, 0.31-0.61). No similar difference was noted between non-Hispanic White Medicare patients and patients of Asian or Other race/ethnicities. The Medicare model also showed that female patients had a lower OR of any versus no treatment than male patients (OR, 0.85; 95% CI, 0.75-0.96). Restricting this analysis to only Medicare patients with supplemental insurance did not affect these findings (Figure C).

Survey vs Definitive Chemoradiation as First Course of Treatment

Controlling for age, sex, race/ethnicity, rurality, SEER stage, and insurance, the OR of receiving surgery versus definitive chemoradiation in non-Hispanic Black patients remained significantly lower than non-Hispanic White patients (OR, 0.67; 95% CI, 0.48-0.92) (Figure C) and remained significantly lower after county-level education status and median household income were added to the model (OR, 0.66; 95% CI, 0.47-0.93). Patients with a race/ethnicity categorized as Other had a higher OR of receiving surgery versus definitive chemoradiation compared to non-Hispanic White patients (OR, 3.21; 95% CI, 1.19-8.65), though only 17 patients were in that subgroup. Patients with TRICARE/Military/VA (OR, 1.51; 95% CI, 1.01-2.26) and Insurance, NOS (OR, 1.36; 95% CI, 1.03-1.79) had a higher OR of receiving surgery versus definitive chemoradiation compared to privately insured patients. Patients with Medicare, Medicaid, and Self Pay/Not Insured/Unknown insurance no longer had a difference in first course treatment of surgery or definitive chemoradiation compared to privately insured patients. We did not see an interaction between race and ethnicity and insurance status

Table 4. Sequential Models of Adjusted Cox Proportional Hazards Regression for the Subset of Medicare Patients With Supplemental Insurance for Overall Survival[a]

Medicare Patients	Model I			Model II			Model IV		
Variable	HR	95% CI	*P* value	HR	95% CI	*P* value	HR	95% CI	*P value*
Age									
Continuous	1.04	1.03–1.04	<0.001	1.04	1.03–1.05	<0.001	1.01	1.01–1.02	<0.001
Sex									
Male	ref			ref			ref		
Female	0.96	0.89–1.04	0.371	1.00	0.92–1.08	0.990	0.94	0.87–1.01	0.108
Race/ethnicity									
Non-Hispanic White	ref			ref			ref		
Non-Hispanic Black	1.01	0.75–1.35	0.963	1.03	0.77–1.38	0.849	0.86	0.64–1.15	0.314
Native American	0.86	0.48–1.57	0.630	0.95	0.52–1.73	0.871	1.17	0.65–2.13	0.599
Asian	1.03	0.46–2.30	0.944	0.72	0.32–1.60	0.415	1.03	0.46–2.31	0.935
Hispanic	0.97	0.67–1.41	0.879	1.11	0.76–1.61	0.587	1.34	0.92–1.95	0.126
Other	1.48	0.662–3.30	0.337	1.57	0.66–3.30	0.268	1.20	0.54–2.68	0.651
Rurality (RUCC)									
Continuous	1.00	0.98–1.02	0.885	1.00	0.98–1.02	0.819	1.00	0.98–1.02	0.750
SEER stage									
Localized				ref			ref		
Regional				1.03	0.89–1.19	0.670	1.21	1.05–1.40	0.009
Distant				2.52	2.20–2.90	<0.001	2.27	1.97–2.62	<0.001
Unstaged				2.28	1.70–3.05	<0.001	1.28	0.95–1.71	0.104
Treatment course									
No treatment							ref		
Definitive chemoradiation							0.31	0.28–0.34	<0.001
Surgery, with or without neoadjuvant and/or adjuvant treatment							0.15	0.13–0.18	<0.001
Unknown							0.52	0.35–0.79	0.002

[a]Model I included age, sex, race/ethnicity, and rurality. Model II included age, sex, race/ethnicity, rurality, and SEER stage. Model III was not completed since all patients had Medicare insurance with supplemental insurance. Model IV included age, sex, race/ethnicity, rurality, SEER stage, and treatment course. Nineteen patients were excluded for missing survival time, sex, and/or rurality. County-level education status and median household income were added to each model, and the results remained consistent with those shown here.

Abbreviations: HR, hazard ratio; SEER, Surveillance, Epidemiology, and End Results; RUCC, Rural-Urban Continuum codes; VA, Veterans Administration.

or resectable versus nonresectable stage when studying the odds of receiving surgery versus definitive chemoradiation, though the sample sizes for some race/ethnicity subgroups were small (data not presented).

Within the subgroup of Medicare patients, non-Hispanic Black Medicare patients showed a lower OR of surgery versus definitive chemoradiation as first course of treatment (OR, 0.57; 95% CI, 0.34-0.93) (Figure E). Restricting this analysis to only Medicare patients with supplemental insurance mitigated this disparity, though the confidence interval was wide due to the lower sample size (OR, 0.89; 95% CI, 0.33-2.43) (Figure F).

Survival Analysis

For patients who were deceased, non-Hispanic Black patients experienced a mean survival of 8.6 months (SD 9.6), and non-Hispanic White patients experienced a mean survival of 9.6 months (SD 12.6). We show the results of sequential adjusted Cox proportional hazards analysis in Table 2 (all patients), Table 3 (Medicare patients), and Table 4 (Medicare patients with supplemental insurance) for risk of death.

Non-Hispanic Black patients had a higher hazard ratio (HR)

for risk of death compared to non-Hispanic White patients in the first 2 models models (HR, 1.18; 95% CI, 1.06-1.31 in Model II, adjusting for age, sex, race/ethnicity, rurality, and SEER stage). Adding insurance in Model III mitigated some of the survival disparity (HR, 1.11; 95% CI, 0.99-1.23), and adding treatment course in Model IV eliminated the survival disparity between non-Hispanic Black and NHW patients (HR, 0.98; 95% CI 0.88-1.09). Including county-level median household income and educational attainment explained some of the survival disparity between non-Hispanic Black and non-Hispanic White patients (HR, 1.10; 95% CI, 0.99-1.23) in Model II when adjusting for age, sex, race/ethnicity, SEER stage at diagnosis, and county-level educational attainment and median household income. Similarly, the survival disparity was minimized by incorporating treatment course (HR, 0.95; 95% CI, 0.85-1.06) when adjusting for age, sex, race/ethnicity, SEER stage at diagnosis, insurance, treatment course, and county-level educational attainment and median household income.

Similarly, for the Medicare patient subgroup, non-Hispanic Black patients had an HR of 1.12 (95% CI, 0.97-1.30) compared to non-Hispanic White patients in the basic model, which

increased to 1.18 (95% CI, 1.02-1.37) when we added SEER stage to the regression (Table 3). This difference in survival was again explained when we added treatment course in the final model (HR, 0.93; 95% CI, 0.80-1.08). County-level educational attainment and median household income had a similar impact on survival in the Medicare patient subgroup as in the full cohort, where it partially explained the survival disparity between non-Hispanic Black and non-Hispanic White patients in Model II (HR, 1.10; 95% CI, 0.94-1.29) and began to reveal a survival advantage for non-Hispanic Black patients when added to the final model (HR, 0.89; 95% CI, 0.76-1.04).

Conversely, we found no survival disparity between non-Hispanic Black and non-Hispanic White Medicare patients with supplemental insurance when restricting the analysis to patients with that insurance in any model (Table 4).

In the final model, which adjusted for age, sex, race/ethnicity, rurality, insurance, SEER stage, and treatment course, Medicare (HR, 1.07; 95% CI, 1.00-1.15), Medicaid (HR, 1.25; 95% CI, 1.11-1.41), and Self Pay/Not Insured/Unknown (HR, 1.16; 95% CI, 1.02-1.31) insurance patients all had higher HRs than patients with private insurance. Female patients had a lower HR (0.94; 95% CI, 0.90-0.99) compared to male patients.

DISCUSSION

We aimed to identify whether race and ethnicity-based treatment and survival disparities existed amongst Wisconsin PDAC patients. We found that non-Hispanic Black patients were less likely to receive any treatment compared to non-Hispanic White patients. Among those patients who received any treatment, non-Hispanic Black patients were less likely to receive surgery compared to non-Hispanic White patients. This racial disparity persisted in Medicare patients. Additionally, non-Hispanic Black patients experienced higher HRs than non-Hispanic White patients in initial survival models. This survival disparity was primarily mitigated by treatment course, with insurance status and county-level median household income playing smaller roles. This suggests that increasing access to, presentation of, and acceptance of treatment may reduce Wisconsin's non-Hispanic Black PDAC survival disparity.

Non-Hispanic Black patients were the only race/ethnicity subgroup that experienced lower odds of receiving any versus no treatment and surgery versus definitive chemoradiation. Asian and patients of Other race/ethnicities and patients with Medicare, Medicaid, TRICARE/Military/VA, Insurance NOS, and Self Pay/Not Insured/Unknown insurance had a lower OR of any versus no treatment but had similar or higher ORs than non-Hispanic White and privately insured patients of receiving surgery versus definitive chemoradiation. This demonstrates that non-Hispanic Black patients were uniquely disadvantaged compared to patients of other races and ethnicities.

These results are consistent with several studies that found treatment disparities for non-Hispanic Black PDAC patients. Zhu et al[14] found that Black patients experienced lower odds of receiving any treatment compared to White patients. Heller et al[5] found that Black patients were less likely to receive chemotherapy for advanced disease than White patients. Several studies investigating disparities in surgical resection for pancreatic cancer found that Black patients were less likely to be offered[9,11] and undergo surgery.[5,6,8,10-12]

Other studies found that non-Hispanic Black patients presented at a later stage than non-Hispanic White patients.[14,15] In our cohort, however, 53.1% of non-Hispanic Black and non-Hispanic White patients presented with distant disease, and a slightly higher percentage of non-Hispanic Black patients presented with local disease than non-Hispanic White patients. Therefore, contrary to other studies, SEER stage at diagnosis does not explain the treatment disparity non-Hispanic Black patients faced in our study.

We noted an interaction between non-Hispanic Black race/ethnicity and insurance status that, when combined, reduced the OR for non-Hispanic Black patients to receive any versus no treatment. Other studies have not found this interaction. In their study of resectable pancreatic cancer patients, Abraham et al found no interaction between insurance and race.[8] Chang et al[16] and Lee et al[17] found that race did not impact pancreatic cancer treatment or survival in health systems where all patients have equal insurance coverage. Such studies suggest that increasing equity in health insurance may mitigate racial disparities.[16-17] Our data suggest, however, that simply providing the lowest level of insurance coverage will not result in equitable treatment for non-Hispanic Black patients. This is evident from our Medicare cohort results, where non-Hispanic Black Medicare patients were 60% less likely to receive any treatment than non-Hispanic White Medicare patients and non-Hispanic Black Medicare supplement patients remained 60% less likely to receive any treatment than their non-Hispanic White counterparts.

We performed 4 sequential models of adjusted Cox proportional hazard regression to identify factors that mitigated the survival disparity we found for non-Hispanic Black patients. non-Hispanic Black patients were at increased risk of death in the first 2 models. Individual-level insurance status and county-level median household income reduced the disparity. In the final model, treatment course explained the disparity for non-Hispanic Black patients, suggesting that appropriate recommendation and communication of treatment benefits to non-Hispanic Black patients—to the end goal of them accepting treatment recommendations—may improve survival and reduce the survival disparity relative to non-Hispanic White patients. Treatment course did not, however, eliminate the survival disparity for patients with Medicaid or no insurance.

A survival disadvantage for non-Hispanic Black patients prior to incorporating treatment has been noted in previous literature.

Riall et a[14] found that Black patients had decreased survival relative to White patients before accounting for resection and similar survival after accounting for resection. Heller et al[5] found a survival disadvantage for Black patients when accounting for demographic and socioeconomic factors and a survival advantage for Black patients when accounting for clinical factors. Alternatively, Nipp et al[18] and Singal et al[19] saw the survival disadvantage for Black patients persist after treatment was included in their analyses.

Our results showing that the survival disparity experienced by non-Hispanic Black patients was mitigated by treatment course suggests that adherence to treatment guidelines can mediate the relationship between non-Hispanic Black race and treatment and survival outcomes. Identifying a patient's prognosis and recommending treatment is based on clinical judgement, and Kirkegard et al[20] found substantial variation in clinicians' assessments of whether a specific patient was a surgical candidate in their European study. Among 19 patients, clinicians from 7 sites only agreed unanimously on 2 patients: 1 resectable and 1 nonresectable. Additionally, the clinicians agreed on whether a patient should undergo potentially curative versus palliative care in fewer than half of the 19 patients. In the United States, several studies have found regional variation, including underutilization, in treatment.[21,22] Finally, treatment at an academic medical center does not mitigate treatment and outcome disparities non-Hispanic Black patients face.[14,23]

Our study, based on registry data from the WCRS, included limitations in terms of the potential biological and social confounding factors available. The WCRS only includes first line of treatment and is not required to include second line treatments. We included age, sex, race/ethnicity, rurality, insurance, SEER stage, and treatment in our analyses, but registry data do not include individual-level socioeconomic status, marital status, educational attainment, income level, or data on comorbidities. Exclusion of comorbidities and individual-level social factors like those stated, as well as others like transportation services and other forms of social capital, may have influenced the racial disparities in treatment and survival. Furthermore, we did not add area-level social factors, such as county level health care access or neighborhood strength or cohesion.[24,25] Additionally, effort was taken to understand if same-type insurance correlated with similar treatment. However, having private insurance or Medicare does not entail the same coverage for all patients, especially across racial lines. As with all registry data, we were also unable to assess recommendations or intent for treatment, only the receipt or lack of receipt of treatment. Finally, even with little missing registry data and a well-powered sample with 8,490 patients, some subgroups had low counts, which resulted in us masking some results.

CONCLUSION

We found that Non-Hispanic Black pancreatic cancer patients face treatment Wisconsin and that this disparity was primarily explained by treatment, with contributions from insurance status and county-level median household income. Future studies of racial disparities in pancreatic cancer need to focus on how care is presented and provided by clinicians and received by non-Hispanic Black patients at all types of treatment facilities. Studies that continue to focus on lifestyle and biological factors, concluding that these factors do not fully explain disparities experienced by non-Hispanic Black patients, miss a key piece of the pancreatic cancer diagnosis and care cycle. Once diagnosed, treatment offers the ability to extend life. In the absence of novel treatments to improve survival, employing culturally humble approaches, including the incorporation of religious beliefs when appropriate, the use of medical interpreters, ensuring input from patient's preferred support people (family, friends), provider-patient racial congruence whenever possible, use of lay and nurse navigators, community outreach, and engagement around cancer treatment has the potential to increase treatment rates among non-Hispanic Black pancreatic cancer patients with available treatments, improve their pancreatic cancer survival, and reduce disparities.

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