Area Socioeconomic Status and Early Onset Rectal Cancer in a Comprehensive Cancer Center: Evidence from Wisconsin

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ABSTRACT

Introduction: The incidence of early-onset rectal cancer has increased over the past 3 decades and the causes are unknown. Neighborhood socioeconomic status, a measure of social and economic characteristics in a given area, may be associated with early-onset rectal cancer through environments that affect diet, exercise, and health care utilization. We investigated the association between neighborhood-level socioeconomic status and age at rectal cancer diagnosis in Wisconsin.

Methods: We utilized data on 172 rectal cancer patients from the Carbone Cancer Center rectal cancer registry. We measured neighborhood socioeconomic status using the Area Deprivation Index, derived from 17 census measures of education, employment, income, and housing, standardized at the state and national levels. Linear and logistic regression models were employed to estimate the association between the Area Deprivation Index and age at diagnosis.

Results: Of the 172 cases of rectal cancer, 47 (27%) were considered early-onset (<50 years). Null associations were observed between the Area Deprivation Index and age at diagnosis using the national- and state-standardized index. Moreover, estimates using the nationally standardized index suggested lower odds of early-onset rectal cancer in lower socioeconomic status neighborhoods (OR$_{Q5}$ = 0.11, 95% CI, 0.01–1.89).

Conclusions: This study initiates research investigating the association between area-level socioeconomic status and early-onset rectal cancer. While we find no association between the Area Deprivation Index and early-onset rectal cancer, we posit these findings are due to the characteristics of our sample. Future studies are needed to comprehensively explore associations between social factors and early rectal cancer outcomes.

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INTRODUCTION

Despite the decline in overall rectal cancer incidence in recent decades, the incidence of early-onset rectal cancer (EORC) has increased annually by 2% to 3% since the mid-1990s.[1] Defined as onset before age 50, EORC prompted recent screening guideline changes: the American Cancer Society and US Preventive Services Task Force now recommend screening beginning at age 45.[2,3] Causes of the increase are unclear; hypotheses include increases in sedentary lifestyle, changes in diet quality, and obesity.[4-6]

Evidence supports an association between neighborhood socioeconomic status (SES) and rectal cancer outcomes, including higher risk of rectal cancer incidence, mortality, and late-stage diagnosis in lower SES areas.[7-11] Neighborhood SES is a relative measure of a given area's social and economic status, via composite indices of census data at the neighborhood level.[12] The environment in which one resides may influence rectal cancer risk by affecting access to health care and screening.[13-15] Other area-level contextual factors such as spaces for physical activity, nutritious food options, and environmental stressors like crime, may influence EORC indirectly through associations with obesity and inflammation.[6,16-20] Previous studies have found that the prevalence of EORC varies geographically,[4,5] but no studies have examined the association between area-level SES and EORC directly.

We evaluated this association using the publicly available and validated Area Deprivation Index (ADI), with the newly established University of Wisconsin (UW) Carbone Cancer Center

Rectal Cancer Registry. The ADI is compiled using 17 census measures of education, employment, income, and housing at the census-block group level and is free to download from the University of Wisconsin Center for Health Disparities Research in the School of Medicine and Public Health.[12] We hypothesized an inverse association between area SES and EORC, where lower SES areas would experience higher rates of EORC.

METHODS

Data

Data were obtained from the UW Carbone Cancer Center Rectal Cancer Registry. The Carbone Cancer Center is a National Cancer Institute (NCI)-designated comprehensive cancer center in Madison, Wisconsin, serving patients from across the state and Midwest. The registry includes 181 adult patients age 18 and older enrolled between 2018 and 2024 who were seen at UW Health with a histologic diagnosis of rectal adenocarcinoma or squamous cell carcinoma of the rectum or anal canal, defined by the International Classification of Diseases for Oncology, Third Edition (ICD-O-3) code C20.9. Patients with squamous cell carcinoma were excluded. All participants provided written consent to participate in the study.

Demographic variables, including sex, race, ethnicity, education, insurance status, alcohol use, tobacco use, and date of diagnosis, were abstracted from electronic health records and stored in REDCap, hosted by the UW-School of Medicine and Public Health.

This study was deemed minimal risk and granted exemption by the UW-Madison Health Sciences Institutional Review Board (IRB-2018-0149). All study procedures conformed to the tenets of the Declaration of Helsinki.

Analytical Cohort

Of 181 registry patients, we excluded those with missing data on age (n=1) and ADI (n=8), of whom only 1 was younger than age 50. For the single participant missing data on tobacco use, the sex-specific mode was used for imputation. Missing data on alcohol use (n=22) and insurance status (n=8) were treated as separate

categories within the respective variable. The final analytic cohort consisted of 172 participants.

Exposure Measurement

Participant addresses were geocoded, and census block-level Federal Information Processing Standards (FIPS) codes were linked to the publicly available ADI.[12] The ADI was derived from 17 census variables in education, income, employment, and housing domains using 2022 American Community Survey

Table 1. Descriptive Statistics of the Carbone Cancer Center Rectal Cancer Registry, 2018–2024

| Variable | Full Sample (N=172) | Early-Onset (EORC) | | Mid-Onset | Late-Onset |
		<45 Years (N=28)	45–49 Years (N=19)	50–64 Years (N=68)	≥65 Years (N=57)
Age at diagnosis (years)	57 (19)	40 (4)	48 (2)	56 (9)	73 (11)
Sex					
Male	111 (65%)	18 (64%)	12 (63%)	47 (69%)	34 (60%)
Female	61 (35%)	10 (36%)	7 (37%)	21 (31%)	23 (40%)
Race/ethnicity					
Non-Hispanic White	163 (95%)	27 (96%)	19 (100%)	62 (91%)	55 (96%)
Non-Hispanic Black	1 (1%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)
Asian	3 (2%)	0 (0%)	0 (0%)	3 (4%)	0 (0%)
Hispanic	3 (2%)	1 (4%)	0 (0%)	1 (1%)	1 (2%)
Missing	2 (1%)	0 (0%)	0 (0%)	1 (1%)	1 (2%)
Alcohol use					
Missing	22 (13%)	5 (18%)	3 (16%)	7 (10%)	7 (12%)
No	40 (23%)	3 (11%)	5 (26%)	14 (21%)	18 (32%)
Yes	110 (64%)	20 (71%)	11 (58%)	47 (69%)	32 (56%)
Tobacco use					
No	96 (56%)	18 (64%)	12 (63%)	37 (54%)	29 (51%)
Yes	76 (44%)	10 (36%)	7 (37%)	31 (46%)	28 (49%)
Insurance status[a]					
Private	131 (76%)	28 (100%)	17 (89%)	54 (79%)	32 (56%)
Medicaid	10 (6%)	0 (0%)	2 (11%)	7 (10%)	1 (2%)
Medicare	23 (13%)	0 (0%)	0 (0%)	2 (3%)	21 (37%)
Missing	8 (5%)	0 (0%)	0 (0%)	5 (7%)	3 (5%)
Bowel disease[b]					
No	167 (97%)	28 (100%)	18 (95%)	68 (100%)	53 (93%)
Yes	5 (3%)	0 (0%)	1 (5%)	0 (0%)	4 (7%)
ADI state quintile					
Q1 (highest SES)	53 (31%)	11 (39%)	5 (26%)	17 (25%)	20 (35%)
Q2	36 (21%)	4 (14%)	9 (47%)	14 (21%)	9 (16%)
Q3	38 (22%)	4 (14%)	2 (11%)	18 (26%)	14 (25%)
Q4	26 (15%)	7 (25%)	2 (11%)	11 (16%)	6 (11%)
Q5 (lowest SES)	19 (11%)	2 (7%)	1 (5%)	8 (12%)	8 (14%)
ADI national quintile					
Q1 (highest SES)	9 (5%)	3 (11%)	1 (5%)	3 (4%)	2 (4%)
Q2	45 (26%)	8 (29%)	5 (26%)	14 (21%)	18 (32%)
Q3	54 (31%)	5 (18%)	10 (53%)	24 (35%)	15 (26%)
Q4	48 (28%)	11 (39%)	3 (16%)	21 (31%)	13 (23%)
Q5 (lowest SES)	16 (9%)	1 (4%)	0 (0%)	6 (9%)	9 (16%)

Abbreviations: ADI, area deprivation index; SES, socioeconomic status.
Data presented as N (%) for categorical variables and median (interquartile range) for continuous variables.
[a]If participants are dually insured by Medicare and private insurance or Medicaid, they are included in the private insurance or Medicaid groups.
[b]Bowel disease includes Crohn's disease and ulcerative colitis.

5-year estimates (2018-2022). Scores reflect relative socioeconomic disadvantage at the census block group level and are standardized state and national levels. The ADI has been scientifically validated in hundreds of studies predicting health outcomes such as obesity,[21] cancer,[22] and COVID-19.[23] Our analyses included both national- and state-standardized ADI measures, represented in quintiles (1 = highest SES, 5 = lowest SES).

Health insurance coverage was included as a secondary exposure, categorized as private insurance, Medicaid, Medicare, or missing. Those with dual Medicare and private insurance or Medicaid coverage were categorized as private insurance or Medicaid to capture socioeconomic differ-

Table 2. The Association Between ADI and Early Rectal Cancer Diagnosis, N = 172

ADI (State Quintiles)	EORC <50 Years (N = 47)	Mid to Late Onset ≥50 Years (N = 125)	EORC vs Mid to Late Onset OR[a] (95% CI)	EORC vs Mid to Late Onset OR[b] (95% CI)
Q1 (highest SES)	16	37	1 (ref)	1 (ref)
Q2	13	23	1.31 (0.53–3.21)	1.86 (0.68–5.10)
Q3	6	32	0.43 (0.15–1.24)	0.58 (0.19–1.78)
Q4	9	17	1.22 (0.45–3.32)	1.30 (0.41–4.14)
Q5 (lowest SES)	3	16	0.43 (0.11–1.70)	0.38 (0.09–1.67)
ADI (National Quintiles)	**EORC <50 years (N = 47)**	**Mid to Late Onset >50 Years (N = 125)**	**EORC vs Mid to Late Onset OR[a] (95% CI)**	**EORC vs Mid to Late Onset OR[b] (95% CI)**
Q1 (highest SES)	4	5	1 (ref)	1 (ref)
Q2	13	32	0.51 (0.12–2.20)	0.48 (0.10–2.36)
Q3	15	39	0.48 (0.11–2.04)	0.57 (0.11–2.76)
Q4	14	34	0.52 (0.12–2.20)	0.57 (0.11–2.85)
Q5 (lowest SES)	1	15	0.08 (0.01–0.93)	0.06 (0.0–0.73)

Abbreviations: ADI, area deprivation index, EORC, early onset rectal cancer, OR, odds ratio; Q, quintile; SES, socioeconomic status.
[a]OR unadjusted for any covariates.
[b]OR adjusted for sex, alcohol, tobacco, and insurance type, and bowel disease.

ences. A subset of participants was missing insurance data because they were deceased at the time of data extraction. Private insurance was defined as employer-sponsored or individually purchased coverage.

Outcome Measurement

Age of diagnosis of rectal cancer was included as a continuous and categorical variable (< 45, 45–49, 50–64, ≥65). EORC was defined as diagnosis before age 50. Mid-onset (50-64 years) and late-onset (≥65 years) categories were combined because of sample size limitations.

Statistical Analysis

Demographic and behavioral characteristics were tabulated by age at diagnosis. We used logistic regression models to assess the association between ADI quintiles and EORC, adjusting for sex (male, female), insurance status (public, private, both), tobacco use (yes, no), alcohol use (yes, no, missing), and bowel disease (yes, no). Those with missing insurance status were excluded from logistic regression models as quasi-separation of values occurred. Additionally, linear regression models examined associations between ADI quintiles and age of diagnosis, adjusting for the same covariates (sex, insurance status, tobacco use, alcohol use, and bowel disease). Secondary analyses evaluated the association between insurance type and age at diagnosis using linear regression, adjusted for sex, tobacco use, and alcohol use.

RESULTS

This study included 172 cases of rectal cancer from the UW Carbone Cancer Center Rectal Cancer Registry; 47 (27%) cases were classified as EORC (Table 1). Overall, 65% of the cohort was male, 95% identified as non-Hispanic White, 64% reported alcohol use, 44% reported tobacco use, 95% had private, public, or combined health insurance coverage, and 3% reported a history of bowel disease. A greater proportion of EORC cases were insured by private insurance (96%) compared to those diagnosed at ages 50 to 64 (79%) or 65 years and older (0%) (Table 1).

The distribution of participants varied across neighborhood SES quintiles standardized at the state and national levels. Participants were more likely to live in the highest neighborhood SES quintile compared with neighborhoods across Wisconsin (31% in Q1), and in mid-tier SES quintiles (quintiles 2-4) compared with neighborhoods across the United States (31% in quintile 3) (Table 1, Supplemental Table 1).

Generally, we did not observe an association between neighborhood SES and EORC using either state- or nationally standardized ADI measures. In models that utilized the state-standardized ADI, the direction of the association was inconsistent: estimates for quintile 2 and quintile 4 suggested higher odds of EORC, whereas quintile 3 suggested lower odds; all confidence intervals passed unity (Table 2). In models that used the nationally standardized ADI measure, participants in the lowest SES neighborhoods (quintile 5) had the lowest odds of EORC (OR, 0.08; 95% CI, 0.01–0.93); however, confidence intervals for all other quintiles passed unity (Table 2). Among participants with private insurance only, associations between ADI and EORC were also null (Supplemental Table 2).

Similarly, linear regression models did not identify a clear association between ADI quintile and the age at rectal cancer diagnosis. In state-standardized models, the direction of association was unclear, with mean age increasing in quintile 5 and decreasing in all other quintiles; only the estimate for quintile 4 reached statistical significance (quintile 4: mean age, 78.52 years; standard error [SE], 2.99) (Table 3). In nationally standardized models, lower SES appeared to correspond with older age at diagnosis (quin-

tile 1: mean age, 74.3 years; standard error [SE], 8.61; quintile 5: mean age, 86.12 years, SE, 4.94; $P=.02$), but statistical significance was not established for quintiles 2-4 (Table 3).

Individual-level insurance type varied greatly by age group. Most participants younger than age 65 had private insurance (86%), whereas those 65 years and older primarily had public insurance (39%) or a combination of public and private coverage (56%), reflecting Medicare eligibility at age 65 (Table 1). To isolate associations between insurance type and diagnosis age, we analyzed participants younger than 65 years and found that insurance type was associated with age at diagnosis: participants with public insurance were, on average, 9.71 years older at diagnosis than those with private insurance (SE, 2.48; $P<.001$), and those with both public and private insurance were 11.50 years older than those with private insurance only (SE, 2.93; $P<.001$) (Supplemental Table 3).

DISCUSSION

This study suggests that area-level SES may not be associated with early-onset rectal cancer in this cohort from a comprehensive cancer center in Wisconsin, contrary to the hypothesis that lower SES may be linked to a higher incidence of EORC. Prior literature indicates that low neighborhood-level SES is associated with increased rectal cancer incidence and late-stage diagnosis.[11,13,22,24-26] Additionally, other studies have reported associations between low SES and limited access to healthy fresh food options and outdoor physical activity areas, which may contribute to a heightened risk of rectal cancer.[27,28]

We hypothesize that our findings may reflect sample characteristics. The majority of the 172 participants in our study self-identified as non-Hispanic White, a population diagnosed with EORC at a lower rate than African American and Hispanic populations.[29] Additionally, most participants had health insurance, which has previously been established as a strong predictor of screening and diagnostic testing completion.[30,31] Finally, the incidence of EORC may be lower at NCI-designated comprehensive cancer centers such as Carbone, since these centers have goals to address inequities in cancer detection and treatment, in addition to providing guideline-concordant care.[32]

Despite null associations between ADI and EORC, we found that individual-level insurance type was associated with age at diagnosis among participants younger than 65 years. Those with public insurance were diagnosed at older ages compared with those with private insurance, suggesting that lack of private coverage may delay screening and diagnostic evaluation. Future research should further investigate the role of insurance coverage in early detection of rectal cancer.

Strengths

This study is, to our knowledge, the first to investigate the association between area-level SES and EORC. Investigating poten-

Table 3. The Association Between ADI and Age of Rectal Cancer Diagnosis, N = 172

ADI (State Quintiles)	Age Estimate[a]	Standard Error (95%)	P value
Q1 (highest SES)	84.80 (ref)	7.74	—
Q2	-4.07	2.58	.11
Q3	-1.62	2.54	.52
Q4	-6.28	2.99	.04
Q5 (lowest SES)	1.13	3.29	.73
ADI (National Quintiles)	**Age Estimate[a]**	**Standard Error (95%)**	**P value**
Q1 (highest SES)	74.3 (ref)	8.61	—
Q2	7.72	4.24	.07
Q3	3.59	4.22	.40
Q4	1.68	4.24	.69
Q5 (lowest SES)	11.82	4.94	.02

Abbreviations: ADI, area deprivation index; SES, socioeconomic status, std err, standard error.
[a]Estimates adjusted for sex, alcohol, tobacco, insurance type, and bowel disease.

tial risk factors for EORC is critical for researchers, clinicians, and policymakers seeking to address the rising incidence among younger adults. Use of the ADI strengthens this study because it is a validated, publicly available, neighborhood-level measure of SES. Its granularity captures variation that broader measures may miss, and its composite nature reflects multiple dimensions of SES more accurately than single indicators such as median household income. Finally, ADI's widespread use also facilitates comparability across studies.

Limitations

Our findings do not come without limitations. The Carbone Cancer Center rectal cancer registry is relatively new (initiated in 2018) and continues to grow, limiting sample size and stratification. Additionally, participants included in this study were highly homogeneous in terms of race (95% non-Hispanic White) and having insurance coverage, which may limit the generalizability of our findings. Finally, individual-level SES measures such as income and education were unavailable in electronic health records, restricting adjustment for these factors.

CONCLUSIONS

This study initiates research on the association between area-level SES and EORC. Although no association was observed between ADI and EORC, insurance type was linked to age at diagnosis, underscoring the importance of individual-level socioeconomic factors. Future studies should examine associations between social factors in diverse populations and early rectal cancer outcomes.

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