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Social vulnerability is associated with advanced breast cancer presentation and all-cause mortality: a retrospective cohort study

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Abstract

Background Disparities in breast cancer mortality persist despite improvements in screening and therapeutic options. Understanding the impact of social determinants of health on disparate breast cancer outcomes is challenging due to heterogeneity of prior assessments. We examined the association between social vulnerability and breast cancer stage at diagnosis and mortality using a standardized measure of population risk for external stressors on health.

Methods Using institutional cancer registry data, female patients aged 18 or older diagnosed with breast cancer between 2012 and 2019 were assigned a 2018 Social Vulnerability Index (SVI) rank based upon home address census tract. We used multinomial logistic regression and Cox proportional hazards model to examine the relationships between SVI and breast cancer stage at diagnosis and all-cause mortality. Covariates included age and, when assessing mortality, cancer stage, comorbidities, body mass index, insurance type, and treatment regimen.

Results A total of 3,499 women with a median age of 59 (IQR 48–69) were included. 60% were White and 31% were Black. Median SVI was 0.36 (IQR 0.14–0.68) and median follow-up was 58 months (IQR 37.3–83.9). On adjusted analyses, each decile increase in SVI resulted in an 11% (OR 1.11, 95% CI 1.06–1.16, $p < .001$) and 15% (OR 1.15, 95% CI 1.09–1.21, $p < .001$) greater odds of presenting with Stage III or IV breast cancer, respectively, compared to DCIS. For patients who underwent surgery ($N = 2916$), each decile increase in SVI was associated with a 6% increase in all-cause mortality risk (HR 1.06, 95% CI 1.01–1.12, $p = .01$). Mortality risk was 1.5 times (HR 1.52, 95% CI 1.02–2.26, $p = .04$) greater for those in the most vulnerable quartile compared to the least vulnerable quartile.

Conclusions Women living in socially vulnerable communities presented with more advanced breast cancers and suffered worse survival. The SVI can be used to identify patients at risk for delayed cancer presentation and increased mortality. This tool can inform geographically targeted resource allocation and interventions aimed at reducing breast cancer care disparities.

Keywords Breast cancer, Social vulnerability, Disparity

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Background

Due to significant advances in screening, diagnosis, and treatment over the last three decades, 5-year survival for patients diagnosed with invasive breast cancer now exceeds 90% for all stages combined [1–4]. However, there has been a differential decrease in mortality, with Black women suffering a 40% higher breast cancer mortality rate than White women, despite having a lower incidence of disease [1, 5]. This disparity can be explained in part by tumor biology and genomics. Black women are more likely to be diagnosed at younger ages with more aggressive breast cancer subtypes, including triple negative tumors [6–8]. While it has been hypothesized that biologic mechanisms, such as variations in genetics, tumor microenvironments, and immunology, may be responsible, breast cancer disparities are not entirely attributable to ancestry-related risk [9–12]. Evidence suggests social and environmental factors contribute significantly to observed inequities. Breast cancer incidence, stage at diagnosis, and survival have all been associated with social determinants of health [13, 14]. Certainly, a complex interplay between social and environmental stressors and individual biologic factors contribute to illness susceptibility and health outcomes across diseases, including breast cancer [12, 15].

While prior research suggests social and environmental disadvantages contribute to poor breast cancer outcomes, there has been significant heterogeneity in the populations and factors studied. In turn, making comparisons across groups, drawing conclusions, and designing generalizable interventions is challenging. Indices, such as the Centers for Disease Control and Prevention's (CDC) Social Vulnerability Index (SVI), can be used to address this by offering standardized measures of social determinants of health. The SVI is a community-level measure of vulnerability based on social, structural, and environmental determinants [16]. This index was initially developed to help emergency response planners and public health officials identify communities in greatest need of support following natural or man-made disasters, but was later introduced in the medical field during the COVID-19 pandemic [17]. The SVI has since been used to identify those at risk for firearm violence, reduced cancer screening, limited access to timely oncologic care, and poor post-operative outcomes, among other applications [18–24].

The SVI can overcome common pitfalls of disparities research by providing a comprehensive, multifactorial assessment of neighborhood-level social determinants of health, accounting for economic stability, social context, and the built environment [25]. The SVI provides a uniquely granular geographical context, which is often neglected in studies that falsely assume spatial uniformity of social variables [26]. Perhaps most importantly, the SVI is standardized and publicly available nationwide, providing a common mechanism for future research and resource allocation in breast cancer care that is widely accessible and replicable. In this study, we aimed to determine the association between social and environmental factors and breast cancer stage at diagnosis and mortality by applying the SVI to institutional registry data. Our institution is uniquely positioned to investigate this topic as we serve a racially diverse catchment area with a wide range of social vulnerability that includes downtown Chicago, the South Side of Chicago, and northwest Indiana.

Methods

We conducted a retrospective cohort study using institutional cancer registry data to identify all female patients aged 18 and over who were diagnosed with breast cancer between January 1, 2012 and December 31, 2019. Follow-up occurred through December 31, 2022. Patients with ductal carcinoma in situ (DCIS) and stage I to IV invasive breast cancer were included. Patients with a diagnosis of lobular carcinoma in situ, phyllodes tumor, sarcoma, neuroendocrine tumor, and lymphoma of the breast were excluded. Patients without a designated home address or with a Post Office Box listed in the electronic health record were excluded due to inability to determine SVI. Prior to analysis, individual patient addresses were geocoded to census tract and then aggregated to maintain confidentiality.

Primary exposure

Our primary exposure was social vulnerability, or a population's susceptibility to negative effects caused by external stressors, as defined by the CDC and Agency for Toxic Substances and Disease Registry [25]. The 2018 SVI accounts for 15 social factors grouped into 4 themes: socioeconomic status, household composition and disability, minority status and language, and housing type and transportation. It is publicly available and measures community vulnerability at the census-tract level. Census tracts are small county sub-divisions, accommodating between 1,200 and 8,000 inhabitants depending on population density [27]. Social vulnerability is scored at both national and state-levels as a percentile ranking from 0 to 1, with 0 representing lowest vulnerability and 1 representing highest vulnerability. Using five-year estimates from the American Community Survey, each census tract receives a percentile rank for overall social vulnerability, as well as for each theme and individual social factor. The SVI is updated on a biannual basis, allowing for contemporaneous investigations. A detailed description of the SVI methods and variable selection was provided by Flanagan et al. [16]

In this analysis, individual patient home address at the time of their last clinical encounter was converted to the

corresponding census tract using the U.S. Census Bureau Geocoder [28]. Patients' addresses at their most recent clinical encounter were used due to the nature of available data. We used the 2018 statewide SVI data to assign each patient an SVI percentile rank based on their home address census tract. The 2018 SVI data reflects five-year American Community Survey estimates, which is concurrent with our study period. SVI scores were examined both categorically as quartiles of increasing vulnerability and as a continuous variable to provide consistency with the published literature. SVI quartiles were determined based on the statewide distribution as follows: Q1 (low vulnerability; 0-0.25), Q2 (low-medium vulnerability; 0.26–0.5), Q3 (medium-high vulnerability; 0.51–0.75), Q4 (high vulnerability; 0.76-1.0). Q1 (low vulnerability) was used as the reference cohort throughout. When analyzed as a continuous variable, SVI scores were rescaled by a factor of 10; hence, a one-unit change in our study represents one decile on the original scale.

Outcomes and covariates

Our primary outcomes of interest included breast cancer stage at time of diagnosis and all-cause mortality. Clinical stage was determined using the American Joint Committee on Cancer staging system. All-cause mortality was defined as death due to any cause within the follow-up period. When evaluating stage at diagnosis, age at diagnosis was included as a covariate. When evaluating mortality, covariates included age and breast cancer stage at diagnosis, comorbidities, body mass index (BMI; underweight, normal, overweight, obese, severely obese), insurance type (private insurance, Medicaid, Medicare, self-pay), and whether the patient received surgery, radiation, and/or chemotherapy for treatment of their breast cancer. The comorbidities evaluated included coronary artery disease, diabetes, hypertension, congestive heart failure, peripheral vascular disease, stroke or transient ischemic attack, chronic obstructive pulmonary disease, end-stage renal disease, liver disease, other metastatic cancer, and acquired immunodeficiency syndrome. Minority status is accounted for in the SVI; therefore, we did not adjust for race or ethnicity in our regression models to avoid the statistical error of double counting [29]. Further, due to historic racial and economic segregation in our catchment area, race and social vulnerability are heavily correlated (particularly Black race and high social vulnerability) and cannot be considered independent variables in our population [30].

Statistical analysis

Data analysis was performed from March 2023 to June 2024. Descriptive statistics were performed using non-parametric ANOVA (Kruskal-Wallis test) and chi-squared analyses. Multinomial logistic regression was used to explore the association between overall SVI and SVI quartiles with breast cancer stage at diagnosis, while controlling for age at diagnosis. Multinomial regression was used because the data did not meet the assumptions of ordinal regression. Cox proportional hazards model was used to investigate the association between overall SVI and SVI quartiles with all-cause mortality within 5 years, stratifying by receipt of surgery and controlling for age, breast cancer stage, select comorbidities, BMI, insurance type, and receipt of chemotherapy. The comorbidities included in the Cox proportional hazards model were determined using backwards selection to optimize model fit and ultimately included congestive heart failure, end stage renal disease, and liver disease. Under these conditions, the models met the proportional hazards assumption, as determined using scaled Schoenfeld residuals. Kaplan-Meier curves were calculated by SVI quartiles for all-cause mortality. Patients entered the model at the date of breast cancer diagnosis and exited the model at the date of last clinical encounter with our institution, or date of death if they experienced mortality, within the study's follow-up period.

Statistical tests were two-sided with a significance level of $\alpha=0.05$. Statistical analyses were performed using SPSS version 28.0.0.0 (IBM Corp; Armonk, NY) and R version 4.3.2, using packages including *nnet* version 7.3.19, *arsenal* version 3.6.3, *survminer* version 0.4.9, *gtsummary* version 1.7.2, and *survival* version 3.5-8 (R Foundation for Statistical Computing; Vienna, Austria). Our study was approved by the University of Chicago Institutional Review Board. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies.

Results

Demographics

We identified 3,499 patients treated for breast cancer between 2012 and 2019 at our urban, academic center. The median age was 59 (IQR 48–69, Table 1). Most patients were White (60%), 31% were Black, and the majority (95%) did not identify as Hispanic or Latino. The most common breast cancer stage at presentation was stage I (41%) followed by stage II (28%). Private insurance was the most common payer type (39%) followed by Medicare (38%). Most patients (83%) underwent surgical treatment of their breast cancer, 42% received chemotherapy, and 56% received radiation. There was a median follow-up of 58 months (IQR 37–84).

Social vulnerability index

Patients resided in 1,376 unique census tracts with a median SVI of 0.36 (IQR 0.14–0.68), representing low-medium social vulnerability. After stratifying by SVI

Table 1 Patient characteristics by Social Vulnerability Index quartile

Characteristic	Overall (*N* = 3499)	Social Vulnerability Index Quartile				
		Q1 (*N* = 1355)	Q2 (*N* = 862)	Q3 (*N* = 657)	Q4 (*N* = 625)	*P*-value
Age in Years, Median (IQR)	59 (48–69)	56 (47–66)	58.5 (48–69)	62 (50–71)	61 (51–71)	< 0.001*
Race, No. (%)						
White	2106 (60.2)	1148 (84.7)	602 (69.8)	239 (36.4)	117 (18.7)	< 0.001*
Black/African American	1088 (31.1)	71 (5.2)	179 (20.8)	368 (56.0)	470 (75.2)	
Asian	141 (4.0)	68 (5.0)	41 (4.8)	25 (3.8)	7 (1.1)	
American Indian or Alaska Native	8 (0.2)	2 (0.1)	3 (0.3)	2 (0.3)	1 (0.2)	
Native Hawaiian/Other Pacific Islander	3 (0.1)	0 (0)	2 (0.2)	1 (0.2)	0 (0)	
More than one Race	100 (2.9)	47 (3.5)	27 (3.1)	13 (2.0)	13 (2.1)	
Unknown	53 (1.5)	19 (1.4)	8 (1.0)	9 (1.4)	17 (2.7)	
Hispanic or Latino Ethnicity, No. (%)	182 (5.2)	45 (3.3)	41 (4.8)	39 (5.9)	57 (9.1)	< 0.001*
Stage at Presentation, No. (%)						
0 (DCIS)	550 (15.7)	225 (16.6)	143 (16.6)	104 (15.8)	78 (12.5)	< 0.001*
I	1425 (40.7)	601 (44.4)	365 (42.3)	246 (37.4)	213 (34.1)	
II	975 (27.9)	371 (27.4)	233 (27.0)	187 (28.5)	184 (29.4)	
III	287 (8.2)	91 (6.7)	65 (7.5)	61 (9.3)	70 (11.2)	
IV	262 (7.5)	67 (4.9)	56 (6.5)	59 (9.0)	80 (12.8)	
BMI, No (%)						
Underweight	66 (1.9)	33 (2.4)	16 (1.9)	10 (1.5)	7 (1.1)	< 0.001*
Normal weight	996 (28.5)	461 (34.0)	267 (31.0)	147 (22.4)	121 (19.4)	
Overweight	971 (27.8)	401 (29.6)	225 (26.1)	195 (29.7)	150 (24.0)	
Obese	1067 (30.5)	337 (24.9)	260 (30.2)	225 (34.2)	245 (39.2)	
Severely Obese	262 (7.5)	74 (5.5)	52 (6.0)	59 (9.0)	77 (12.3)	
Unknown	137 (3.9)	49 (3.6)	42 (4.9)	21 (3.2)	25 (4.0)	
Insurance Type, No. (%)						
Private	1359 (38.8)	651 (48.0)	332 (38.5)	202 (30.7)	174 (27.8)	< 0.001*
Medicaid	89 (2.5)	20 (1.5)	12 (1.4)	24 (3.7)	33 (5.3)	
Medicare	1345 (38.4)	477 (35.2)	328 (38.1)	287 (43.7)	253 (40.5)	
Self-Pay	282 (8.1)	79 (5.8)	74 (8.6)	69 (10.5)	60 (9.6)	
Unknown	424 (12.1)	128 (9.4)	116 (13.5)	75 (11.4)	105 (16.8)	
Comorbidities, No (%)						
Coronary Artery Disease	194 (5.5)	31 (2.3)	28 (3.2)	60 (9.1)	75 (12.0)	< 0.001*
Diabetes	414 (11.8)	68 (5.0)	72 (8.4)	120 (18.3)	154 (24.6)	< 0.001*
Hypertension	1211 (34.6)	282 (20.8)	260 (30.2)	333 (50.7)	336 (53.8)	< 0.001*
Congestive Heart Failure	120 (3.4)	12 (0.9)	13 (1.5)	39 (5.9)	56 (9.0)	< 0.001*
Peripheral Vascular Disease	68 (1.9)	3 (0.2)	15 (1.7)	16 (2.4)	34 (5.4)	< 0.001*
Stroke or Transient Ischemic Attack	225 (6.4)	36 (2.7)	46 (5.3)	56 (8.5)	87 (13.9)	< 0.001*
Chronic Obstructive Pulmonary Disease	137 (3.9)	19 (1.4)	24 (2.8)	44 (6.7)	50 (8.0)	< 0.001*
End-Stage Renal Disease	31 (0.9)	1 (0.1)	6 (0.7)	10 (1.5)	14 (2.2)	< 0.001*
Liver Disease	188 (5.4)	57 (4.2)	33 (3.8)	45 (6.8)	53 (8.5)	< 0.001*
Other Metastatic Cancer	80 (2.3)	24 (1.8)	18 (2.1)	21 (3.2)	17 (2.7)	0.19
Acquired Immunodeficiency Syndrome	4 (0.1)	0 (0)	1 (0.1)	1 (0.2)	2 (0.3)	0.27
Treatment Received, No (%)						
Surgery	2916 (83.3)	1191 (87.9)	720 (83.5)	539 (82.0)	466 (74.6)	< 0.001*
Chemotherapy	1478 (42.2)	584 (43.1)	342 (39.7)	287 (43.7)	265 (42.4)	0.39
Radiation	1946 (55.6)	774 (57.1)	480 (55.7)	382 (58.1)	310 (49.6)	0.01*
Follow-Up in Months, Median (IQR)	58.0 (37.3–83.9)	59.6 (39.8–84.4)	59.6 (38.2–86.0)	56.7 (35.8–82.2)	52.4 (29.9–80.6)	< 0.001*

Q1 = low social vulnerability; Q2 = low-medium social vulnerability; Q3 = medium-high social vulnerability; Q4 = high social vulnerability; IQR = Interquartile Range; BMI = Body Mass Index; *Statistically significant with α = 0.05

quartile, we found 39% of patients lived in the least vulnerable communities (Q1) and 18% lived in the most vulnerable communities (Q4). Notably, the least vulnerable quartile (Q1) was comprised of 85% White patients and 5% Black patients, whereas the most vulnerable quartile (Q4) included 75% Black patients and 19% White patients.

Breast cancer stage at diagnosis

We found a positive association between overall SVI and breast cancer stage at diagnosis, such that increasing social vulnerability was associated with more advanced cancer stage at diagnosis. After controlling for age, multinomial logistic regression demonstrated that for each decile increase in SVI, the odds of presenting with clinical stage II, III, or IV breast cancer as compared to DCIS increased by 4% (OR 1.04, 95% CI 1.00-1.08, $p=.04$), 11% (OR 1.11, 95% CI 1.06–1.16, $p<.001$) and 15% (OR 1.15, 95% CI 1.09–1.21, $p<.001$), respectively (Table 2). For patients from communities with medium-high social vulnerability (Q3), the odds of presenting with Stage III or IV disease increased by 58% (OR 1.58, 95% CI 1.06–2.36, $p=.03$) and 85% (OR 1.85, 95% CI 1.21–2.82, $p<.01$), respectively, compared to those from low vulnerability communities (Q1). Patients from high vulnerability communities (Q4) had more than double the odds of presenting with stage III disease (OR 2.43, 95% CI 1.62–3.66, $p<.001$) and more than triple the odds of presenting with stage IV disease (OR 3.33, 95% CI 2.19–5.05, $p<.001$) compared to their low vulnerability counterparts.

All-cause mortality

Death occurred in 556 patients (16%). Increasing breast cancer stage was associated with increasing mortality ($p<.001$). Age at diagnosis was also significantly associated with mortality (HR 1.03, 95% CI 1.02–1.04, $p<.001$). There was a significant difference in death rates observed by SVI quartile: Q1, 10%; Q2, 13%; Q3, 21%; Q4, 27% ($p<.001$). On univariate analysis, women from communities with medium-high (Q3) and high (Q4) social vulnerability had a higher risk of mortality (Q3: HR 2.12, 95% CI 1.62–2.77, $p<.001$; Q4: HR 3.12, 95% CI 2.43–4.02, $p<.001$) compared to those from low vulnerability communities (Q1). The Kaplan-Meier survival analysis curve by SVI quartiles is presented in Fig. 1. After stratifying by receipt of surgery, the multivariable Cox proportional hazards model revealed that each decile increase in SVI was associated with a 6% increase in five-year mortality risk (HR 1.06, 95% CI 1.01–1.12, $p=.01$) for patients who underwent an operation ($N=2916$; Table 3). When analyzing by SVI quartile, patients from the most vulnerable communities (Q4) had 1.5 times greater mortality risk (HR 1.52, 95% CI 1.02–2.26, $p=.04$) compared to those from the least vulnerable communities (Q1). Differences in characteristics between the operative and nonoperative patients, as well as Cox proportional hazard model results for the patients who did not undergo surgery ($N=576$), are reported in Additional Files 1 and 2, respectively.

Discussion

In this retrospective cohort study, we found women living in socially vulnerable communities presented with more advanced stages of breast cancer and experienced increased all-cause mortality following a breast cancer diagnosis. These findings are consistent with prior research suggesting that resource deprivation and limited access to care contribute to worse oncologic outcomes [13]. The SVI provides a uniquely granular and comprehensive multifactorial assessment of social and environmental drivers of inequitable access to and receipt of breast cancer care [25].

While exhaustive research efforts have been dedicated to detecting and assessing racial disparities in breast cancer survival, the CDC's SVI provides additional context to better understand the factors underlying these pervasive disparities. This tool defines vulnerable populations more broadly by incorporating an extensive array of community-level social and environmental factors including, but not limited to, minority status. The striking overlap between Black race and social vulnerability in our cohort highlights the enduring deleterious impact of structural racism and discriminatory housing policies that have resulted in residential segregation [12, 31, 32]. Racial and economic segregation have been linked to worse cancer outcomes, including later-stage breast

Table 2 Multinomial logistic regression of social vulnerability with breast cancer stage, adjusted for age

SVI	Stage I		Stage II		Stage III		Stage IV	
	OR (95% CI)	*P*-Value	OR (95% CI)	*P*-Value	OR (95% CI)	*P*-Value	OR (95% CI)	*P*-Value
Overall SVI	0.98 (0.94–1.01)	0.18	1.04 (1.00-1.08)	0.04*	1.11 (1.06–1.16)	< 0.001*	1.15 (1.09–1.21)	< 0.001*
Q1	*Reference*							
Q2	0.93 (0.73–1.19)	0.57	1.00 (0.77–1.31)	0.99	1.17 (0.80–1.71)	0.43	1.30 (0.86–1.96)	0.22
Q3	0.83 (0.63–1.10)	0.20	1.12 (0.84–1.50)	0.44	1.58 (1.06–2.36)	0.03*	1.85 (1.21–2.82)	< 0.01*
Q4	0.96 (0.71–1.30)	0.78	1.48 (1.08–2.02)	0.02*	2.43 (1.62-3.66)	< 0.001*	3.33 (2.19–5.05)	< 0.001*

SVI = Social Vulnerability Index; OR = Odds Ratio; CI = Confidence Interval; Q1 = low social vulnerability; Q2 = low-medium social vulnerability; Q3 = medium-high social vulnerability; Q4 = high social vulnerability; *Statistically significant with α = 0.05

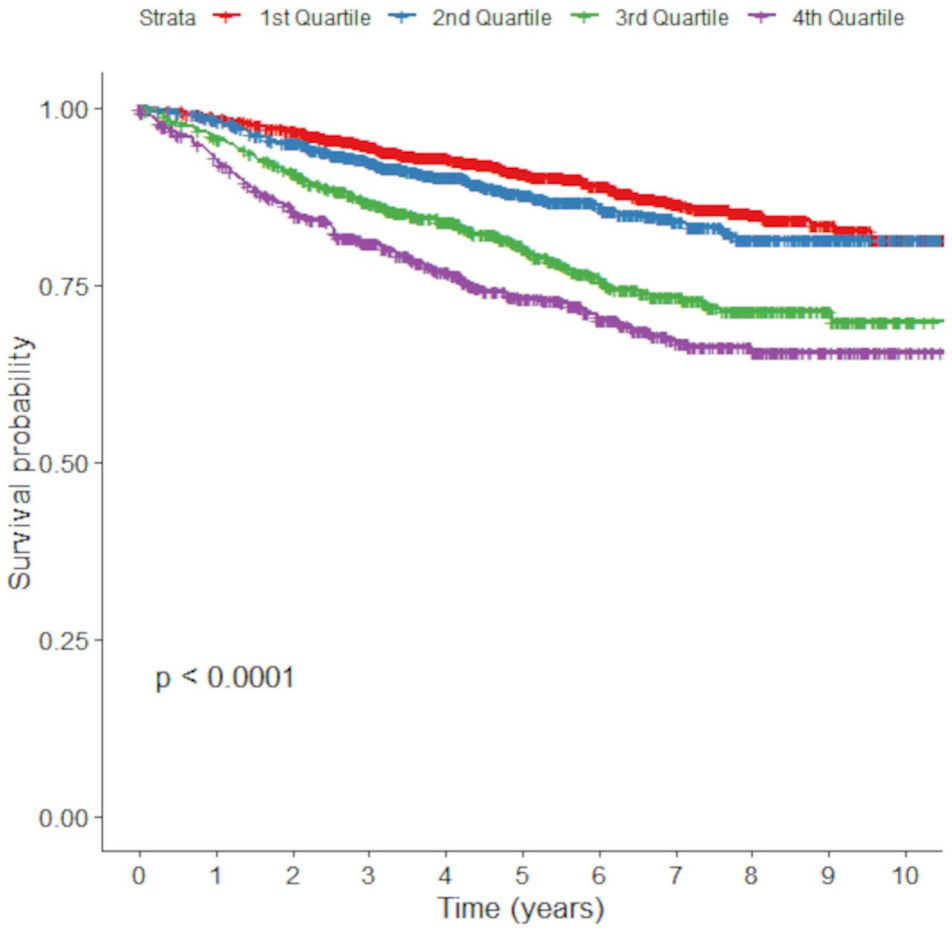

Fig. 1 Kaplan-Meier survival curve for all-cause mortality by Social Vulnerability Index quartiles. 1st Quartile (Q1) = low social vulnerability; 2nd quartile (Q2) = low-medium social vulnerability; 3rd Quartile (Q3) = medium-high social vulnerability; 4th Quartile (Q4) = high social vulnerability

Table 3 Cox proportional hazards model of social vulnerability with mortality for patients who underwent surgery

Social Vulnerability	Univariable		Multivariable	
	Hazard Ratio (95% CI)	***P*-value**	**Hazard Ratio (95% CI)**	***P*-value**
Overall SVI	1.14 (1.09–1.20)	< 0.001*	1.06 (1.01–1.12)	0.01*
Q1 (low)	*Reference*		*Reference*	
Q2 (low-medium)	1.23 (0.83–1.84)	0.30	1.11 (0.74–1.65)	0.62
Q3 (medium-high)	2.03 (1.39–2.96)	< 0.001*	1.47 (1.00-2.18)	0.05
Q4 (high)	2.64 (1.82–3.81)	< 0.001*	1.52 (1.02–2.26)	0.04*

CI = Confidence Interval; SVI = Social Vulnerability Index; *Statistically significant with α = 0.05

cancer diagnoses and increased breast cancer mortality [32–37]. For decades, it has been hypothesized that the cumulative burden of chronic stress experienced by marginalized groups secondary to social inequity hastens physical health deterioration [38, 39]. Ultimately, investigating the underlying mechanisms driving racial disparities enables the identification of modifiable risk factors that can inform future targeted interventions [40].

Several studies have analyzed possible opportunities for tailored outreach and resource allocation based on measures of neighborhood disadvantage. For example, Bauer et al. [20] examined the association between county-level SVI and timely, guideline-concordant screening rates for various cancers, including breast. After adjusting for urban-rural status, percentage of uninsured adults, and primary care physician rate per 100,000 residents, multivariable regression showed that women from the most vulnerable quintile had 8% lower odds of receiving screening mammography compared to the those in the least vulnerable quintile (OR 0.92, 95% CI 0.90–0.93). Further, a recent analysis demonstrated that socioeconomically deprived neighborhoods were less likely to have Food and Drug Administration- or American College of Radiology (ACR)-accredited mammographic

facilities, accredited stereotactic biopsy or breast ultrasound facilities, and ACR Breast Imaging Centers of Excellence compared to less disadvantaged nieghborhoods [41]. Similarly, more deprived U.S. counties also have persistently elevated rates of late stage breast cancer diagnoses [42]. These finding demonstrate that reduced mammography access, uptake, and quality can contribute to delayed breast cancer diagnoses observed in women from vulnerable communities.

Such regional disparities could inform geographically targeted interventions to improve access to breast cancer screening and diagnostics. Patient navigation and mobile mammography units are two interventions that have been proposed and deployed with varying efficacy [43, 44]. A systematic review of mobile mammography clinics concluded that, while mobile units successfully reach underserved women, challenges persist regarding patient retention and appropriate follow-up of abnormal findings [43]. A spatial analysis of mammography facility distributions in Delaware demonstrated a relative dearth of mammography sites in census tracts that were more rural and housed more Black women. A catchment- and location-allocation analysis was then used to identify candidate locations for additional mammography centers in the state [45]. Similarly, indices like the SVI could be used to prioritize resource allocation to disadvantaged communities, thereby fostering a more equitable distribution of important screening and cancer-related healthcare services.

Further, public policy aimed at improving access to care may also be essential to lessening the differential breast cancer survival gap that we and others have demonstrated. Barnes et al. [10] conducted a study of over two million adult patients with cancer using Surveillance, Epidemiology, and End Results (SEER) program data to determine if state-level assistance spending is associated with overall survival. Breast was the most common cancer site in the cohort studied. Notably, patients with cancer living in states in the top tertile of public assistance spending experienced greater 6-year overall survival compared to patients residing in the lowest tertile states (0.09%, 95% CI 0.04–0.13%, per $100 per capita, $p<.001$). This improvement in survival was even more pronounced in non-Hispanic Black individuals. Other studies confirm that public policy aimed at improving access to care, namely Medicaid expansion, can result in earlier cancer detection, reductions in treatment delays, and improved survival [10, 46–48]. The positive impact of Medicaid expansion was similarly augmented in minority patients [47, 48]. Social policies, such as a conditional cash-transfer program, have been shown to mitigate the association between income segregation and breast cancer mortality abroad, as well [49]. Ultimately, further research is needed to develop and implement effective strategies to facilitate early detection, guideline-concordant treatment, treatment completion, and survivorship care of vulnerable patients with breast cancer.

This study has several limitations. The data was obtained from a single-center registry; however, the cohort includes a large minority population as well as representation across census tracts with varying social vulnerability. The underrepresentation of minority groups in national cancer registries, including the National Cancer Database and SEER, necessitates institutional investigations from centers that serve diverse catchment areas [50, 51]. Further, this is a retrospective analysis with a median follow-up of nearly 5 years. While five-year mortality from invasive breast cancer has dramatically improved, results from our Kaplan-Meier analysis over 10 years suggest the survival gap between patients from communities with high versus low social vulnerability continues to widen with time. We also could not account for individuals' home address stability over the duration of the study period; however, the sociology literature on housing mobility suggests that, although people from disadvantaged neighborhoods move more often, there is limited upward mobility [52]. Next, we examined the endpoint of all-cause mortality due to the nature of the available data; however, our findings are consistent with prior studies examining breast cancer-specific survival [13]. Additionally, we could not account for several potential confounders, including hormone receptor status and completion of endocrine therapy, which can impact breast cancer-specific mortality. Finally, the utilization of composite community-level indices to evaluate individual-level outcomes invites the possibility of ecological fallacy, though accuracy improves with descending geographic levels [53]. Thus, investigating area-based measures at a granular geographic scale, as we did in this analysis, is crucial to reducing bias.

Conclusions

In summary, women living in socially vulnerable communities presented with more advanced breast cancers and had disparate mortality following breast cancer diagnosis. The SVI can help identify modifiable social and environmental factors underlying these disparities, providing targets for geographically tailored strategies to improve access to care. Further research is needed to develop, implement, and evaluate such interventions. The SVI provides a common metric for future breast cancer research that is both widely available and, importantly, replicable.

Abbreviations

CDC	Centers for Disease Control and Prevention
SVI	Social Vulnerability Index
DCIS	Ductal carcinoma in situ
BMI	Body mass index

FDA Food and Drug Administration
ACR American College of Radiology
SEER Surveillance, Epidemiology, and End Results

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13058-024-01930-6.

Additional File 1: Provides additional data entitled "Patient characteristics by receipt of surgery for treatment of breast cancer." This supplemental data presents the differences in characteristics between the patients with breast cancer managed nonoperatively versus operatively

Additional File 2: Provides additional data entitled "Cox proportional hazards model of social vulnerability with all-cause mortality for patients who did not undergo breast cancer surgery (N = 576)." This supplemental data presents the Cox proportional hazard model results for the patients who did not undergo surgery

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Not applicable.

Author contributions
All authors contributed to the study design, data interpretation, and manuscript review. A.P. and S.S. acquired the data. A.P., R.N., and A.B. analyzed the data. K.C. and S.S. wrote the main manuscript text.

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Data availability
The dataset generated and analyzed during the current study is not publicly available due to the inclusion of protected health information, such as the patient addresses used to determine Social Vulnerability Index rank, that would compromise patient privacy.

Declarations

Ethics approval and consent to participate
This study was approved by the University of Chicago Institutional Review Board (IRB 2022 – 1049) and a waiver for consent was obtained.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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