Disparities in Prostate Cancer Survival According to Neighborhood Archetypes, A Population-Based Study

Mindy C. DeRouen, Juan Yang, Jennifer Jain, Margaret M. Weden, Scarlett L. Gomez, and Salma Shariff-Marco

OBJECTIVES To examine survival among men with prostate cancer according to neighborhood archetypes. As an advancement beyond measures of neighborhood socioeconomic status (nSES) or specific measures of the neighborhood environment, archetypes consider interactions among many social and built environment attributes.

METHODS Neighborhood archetypes for California census tracts in the year 2000 were previously developed through latent class analysis of 39 measures of social and built environment attributes. We assessed associations between archetypes and overall and prostate cancer-specific survival in this population-based study using geocoded cancer registry data for prostate cancer patients diagnosed 1996-2005 in California, followed through 2017 (n = 185,613). We used Cox proportional hazard models stratified by race/ethnicity and adjusted for age at diagnosis, year of diagnosis, tumor factors, treatment, marital status and cluster effect by census tract. Additional analyses examined associations between race/ethnicity and survival, while accounting for neighborhood archetypes.

RESULTS We observed disparities in overall and prostate cancer-specific risk of death by neighborhood archetypes. Classes with the highest risk of death were defined by lower nSES, but also other domains such as rural/urban status, racial/ethnic composition or age of residents, commuting and traffic patterns, residential mobility, and food environment. Associations between archetypes and survival varied by race/ethnicity.

CONCLUSION We observe interactions among several domains of neighborhood social and built environment attributes as demonstrated by the associations between neighborhood archetypes and prostate cancer survival. These results highlight opportunities for multilevel neighborhood interventions to reduce neighborhood disparities in prostate cancer survival. UROLOGY 163: 138–147, 2022. © 2021 Elsevier Inc.

Prostate cancer is the most common cancer and second-leading cause of cancer death among males in the United States.[1] Many studies of prostate cancer survival have established an independent effect of neighborhood socioeconomic status (nSES) on prostate cancer survival after accounting for individuals' race/ethnicity as well as clinical and treatment factors.[2–9] These studies have largely utilized single measures[3,6,10] or composite indices of nSES or disadvantage[2,4,5,7–9,11–13] and indicate greater risk of death for individuals residing in lower SES neighborhoods.[14] A recent multilevel study from our group additionally established the independent association of nSES and prostate cancer survival in models adjusted for individual-level SES (ie education), medical history, behavioral factors, hospital level factors, and a number of specific measures of neighborhood social and built environments.[9] Of note, crowding and the food environment were associated with overall prostate cancer survival in minimally-adjusted models, but did not account for the association between lower nSES and greater risk of death in fully-adjusted models.[9] These results highlight one of the drawbacks of examining each neighborhood attribute independently, and even using indices of a single neighborhood domain like the nSES

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From the Department of Epidemiology & Biostatistics, University of California, San Francisco (UCSF), San Francisco, California; the UCSF Helen Diller Family Comprehensive Cancer Center, San Francisco, California; the Greater Bay Area Cancer Registry, San Francisco, California; and the RAND Corporation, Santa Monica, California

Address correspondence to: Salma Shariff-Marco, Ph.D., M.P.H., Department of Epidemiology and Biostatistics, 550 16th Street, 2nd Floor, San Francisco. E-mail: salma.shariff-marco@ucsf.edu

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index. Though these are the most common approaches, they provide limited ability to understand the complex interactions among multiple attributes of social and built neighborhood environments. In fact, it is unlikely that any one single attribute of neighborhoods (eg poverty or nSES) or even one neighborhood domain (eg food environment) accounts for neighborhood impact on cancer survival. Rather, it is more likely that a multitude of neighborhood domains and interactions across domains influence cancer outcomes.[15–19]

We developed neighborhood archetypes for California based on models fitted with 39 separate measures representing several domains of neighborhood social and built environments. [20,21] Archetypes serve as a powerful tool to understand the interaction effects among different attributes within and across domains; they have been previously associated with disparities in breast cancer survival that vary by individual race/ethnicity.[20,21] Here, we examined associations between a 9-class set of neighborhood archetypes developed for Census year 2000 tracts and survival among males with prostate cancer identified through the California Cancer Registry (CCR). Overall and prostate cancer-specific survival are examined, stratified by patient race/ethnicity. Given that several previous studies of racial/ethnic disparities in prostate cancer survival show that nSES accounted for or attenuated racial/ethnic disparities,[2,3,5–9] we also examined whether the 9-class neighborhood archetype accounted for racial/ethnic disparities.

METHODS

Prostate Cancer Cases

We identified 185,613 males diagnosed with a first primary invasive prostate cancer [International Classification of Disease for Oncology, 3rd Edition, (ICD-O-3) site code C61.9] from the California Cancer Registry (CCR) from 1996 through 2005, a 10-year period around the 2000 Census that provides at least 12-years of follow-up time for assessing survival. Data on age at diagnosis, race/ethnicity (non-Hispanic [NH] White, NH Black, Asian and Pacific Islander [API], Hispanic, Other), marital status, tumor characteristics at diagnosis including SEER summary stage and grade; and treatment modalities such as chemotherapy, radiation, and surgery are available in the CCR by routine abstraction from medical records. Underlying causes of death, coded in International Classification of Diseases, 9th edition (ICD-9) before December 31, 1998, and in 10th edition (ICD-10) after January 1st, 1999, were obtained from death certificates, and deaths assigned codes 185.0 − 185.9 (ICD-9) or C61.0 − C61.9 (ICD-10) were identified as due to prostate cancer. On the basis of the geocodes obtained from their residential address at diagnosis available from the CCR, each case record was appended to neighborhood archetypes based on 2000 Census tract IDs.

Neighborhood Archetypes

Neighborhood archetypes were previously defined for California Census 2000 and 2010 block-groups and tracts, resulting in 5-class and 9-class models.[20,21] This study utilizes the 9-class model, which maximizes observations of relevant interactions among neighborhood domains, compared to the 5-class model. Census 2000 tracts were chosen to (1) provide sufficient prostate cancer case counts compared to Census block groups and (2) provide a longer follow-up period and thus sufficient deaths to examine survival. In this study, census tracts serve as proxies for neighborhoods; on average, census tracts in CA include 4500 persons.

Development of the neighborhood archetypes has been described in detail elsewhere.[20,21] Briefly, archetype models were defined using latent class analysis with 39 measures characterizing several domains of neighborhood social and built environments (ie demographics and household composition, immigration, nSES, walkability, residential mobility, commuting, rural/urban status, land use, and food environment) available from the California Neighborhoods Data System (CNDS).[22] Like principal components analysis, latent class analysis is a data reduction method, but while principal components analysis is a linear combination of variables, latent class analysis seeks to define the underlying latent variable that results in relationships between the modeled variables. In addition, latent class analysis accepts both continuous and categorical variables. Resulting neighborhood archetypes were named and described according to their strongest components.[20,21] Within the 9-class model utilized in this study, *inner city* neighborhoods (16.4% of census tracts) are densely populated, lower SES tracts with more rental/vacant housing units and unhealthy food outlets; inner city neighborhoods are enclaves for Black and Hispanic residents* and have more working-class residents. *New urban/pedestrian* neighborhoods (13.2%) are downtown tracts with highly mixed land use, high racial/ethnic diversity (exclusive of Hispanic ethnicity) with residents that are predominantly young, single millennials and gen-Xers. *Upper middle-class suburb* neighborhoods (12.1%) have high nSES, fewer female-headed households, low residential mobility with more green space and recreational facilities and more residents who are midlife and NH White or API. *High status* neighborhoods (11.6%) are high SES tracts with older, NH White (Baby Boomer) residents with more healthy food outlets and recreational facilities. *City pioneer* neighborhoods (11.1%) are within a city, but not right downtown (ie short, active commuting); they are lower middle-class tracts with high mixed land-use, high diversity in race/ethnicity, immigration status, and language, and residents that are either single, young adults or elderly. *Suburban pioneer* neighborhoods (10.0%) are also within a city, but not right downtown; they are middle class tracts with high mixed land-use, high diversity in race/ethnicity, immigration status, and language, but have more resident families. *Hispanic small town* neighborhoods (10.1%) are lower-middle SES tracts with some mixed land use, short commutes, low traffic density, fewer green areas, unhealthy food outlets, and are Hispanic enclaves (although residents are not necessarily foreign-born). *Mixed-SES class suburb* neighborhoods

* *We conceptualize racial/ethnic composition measures as expressing the persistent and long-term consequences of policies enforcing and perpetuating racial/ethnic residential segregation. As such, neighborhoods with high non-White racial/ethnic composition at the neighborhood level may correlate with adverse neighborhood social and built environments due to racial/ethnic residential segregation and resultant neighborhood disinvestment. However, we also hold that residents of these same neighborhoods may have protective experiences in their neighborhoods due to co-racial/ethnic support, support for positive cultural diet or social norms, and protection from experiences of structural and interpersonal discrimination. Our interpretation of results including these measures are based on this conceptualization. Ongoing work seeks to include and directly measure racial/ethnic residential segregation, social support, and experiences of discrimination.*

(7.9%) have some mixed land-use, no unhealthy food outlets, more recreational opportunities, more commuting, less street connectivity and lower traffic density; residents of *mixed-SES class suburbs* are predominantly middle-class working families. *Rural/micropolitan* neighborhoods (7.7%) are more rural neighborhoods of lower SES, with older, NH White residents, and single-headed households.

Survival Analyses

Survival time was computed as months from the date of diagnosis to the end of follow up, defined as the first occurrence of date of death, date of last known contact, or study end date (December 31, 2017; the most recent vital status data available). For prostate cancer-specific survival analysis, individuals who died from non-prostate cancer causes were right censored at the time of death. Hazard ratios (HRs) and 95% confidence intervals (CIs) from Cox proportional hazards regression were calculated to assess associations between neighborhood archetypes and overall or prostate cancer-specific survival. The proportional hazards assumption was verified by assessing the correlation between weighted Schoenfeld residuals and logarithmic transformation of survival time. No violations of the assumption were observed. The minimally-adjusted models were adjusted for age at diagnosis (in years), year of diagnosis (calendar year), race/ethnicity, and SEER summary stage. Fully-adjusted models additionally included grade, chemotherapy, radiation, surgery, and marital status. All models were also adjusted for clustering by census tract using robust sandwich covariance matrix estimates. P-values for the interaction of race/ethnicity and neighborhood archetype were <0.0001 and 0.0058 for the full model of overall and prostate cancer-specific survival, respectively. Thus, all models are stratified by race/ethnicity.

In order to assess whether neighborhood archetypes account for racial/ethnic disparities, HRs and 95% CIs from Cox proportional hazards regression were calculated to assess associations between race/ethnicity and overall or prostate cancer-specific survival. The base model to assess racial/ethnic disparities in the study population were adjusted for age at diagnosis, year of diagnosis, SEER summary stage, and clustering by census tract. Then, sequential models were adjusted for (1) additional tumor and treatment factors (ie grade, chemotherapy, radiation, and surgery) and marital status followed by (2) census tract-level 9-class archetype.

All statistical tests were carried out using SAS software version 9.3 (SAS Institute, Cary, North Carolina). All P-values reported were two-sided, and those that were < 0.05 were considered to be statistically significant.

RESULTS

Table 1 shows the distribution of demographic and clinical characteristics according to 9-class neighborhood archetypes among males with prostate cancer. The majority of NH White males diagnosed with prostate cancer resided in *high status* (23.5%) while the majority of API males resided in *upper-middle class* (24.8%) neighborhoods. The majority of Hispanic and NH Black males resided in *inner city* neighborhoods (27.5% and 28.2%, respectively), while only 3.8% of NH White males diagnosed resided in *inner city* neighborhoods. Supplemental Table 1 shows the distribution of demographic and clinical characteristics according to race/ethnicity among males diagnosed with prostate cancer.

Neighborhood Archetype Disparities

Fig. 1 shows HRs and 95% CIs for analyses of overall and prostate cancer-specific survival according to neighborhood archetypes among all males and for strata representing racial/ethnic groups. The *upper middle-class suburb* neighborhood is used as reference, as this neighborhood was most frequently associated with lowest risk of death. Supplemental Tables 2 and 3 show all tabulated results of these minimally- and fully-adjusted models. For overall survival among males of all races/ethnicities, HRs ranged from equivocal among males residing in *high status* neighborhoods (HR = 1.00, 95% CI = 0.97 to 1.02) to 1.44 (95% CI = 1.40 to 1.48) and 1.43 (95% CI = 1.40 to 1.47) among those residing in *Hispanic small town* and *inner city* neighborhoods, respectively. Results for prostate cancer-specific survival are similar.

Neighborhood Archetype Disparities Among Racial/Ethnic Groups

Among NH White males, all archetypes, except for *high status* neighborhoods, were associated with a greater risk of death relative to *upper middle-class suburbs*, with HRs clustering into three groups; 1) residents of *new urban/pedestrian* neighborhoods had slightly increased risk of death (HR = 1.05, 95% CI = 1.02, 1.08); 2) residents of *mixed SES-class suburb*, *rural/micropolitan*, *suburban pioneer*, and *city pioneer* neighborhoods had moderately increased risk of death with HRs ranging from 1.20 (95% CI = 1.16 to 1.24) to 1.28 (95% CI = 1.24 to 1.33); and 3) *Hispanic small town* and *inner city* neighborhoods had high increased risk of death with HRs of 1.41 (95% CI = 1.36 to 1.45) and 1.42 (95% CI = 1.37 to 1.48), respectively. Among NH Black males, relative to *upper middle-class suburb* residents, residents of *new urban/pedestrian* and *mixed SES-class suburb* neighborhoods had slightly increased risk of death with HRs of 1.15 (95% CI = 1.04 to 1.27) and 1.16 (95% CI = 1.03 to 1.31), respectively; residents of *rural/micropolitan* and *suburban pioneer* neighborhoods had moderately increased risk of death, (HR=1.29, 95% CI = 1.12 to 1.49; HR = 1.31, 95% CI = 1.18 to 1.45; respectively), and residents of *city pioneer, Hispanic small town* and *inner city* neighborhoods had high increased risk of death with HRs ranging from 1.40 (95% CI = 1.27 to 1.54) to 1.43 (95% CI = 1.31 to 1.56). Relative to Hispanic males in *upper middle-class suburb,* Hispanic males who resided in *rural/micropolitan*, *city pioneer,* and *inner city* neighborhoods had slightly increased risk of death with HRs ranging from 1.14 (95% CI = 1.02 to 1.26) to 1.16 (95% CI = 1.08 to 1.25) and residents of *Hispanic small town* neighborhoods had moderately increased risk of death (HR = 1.26, 95% CI = 1.16 to 1.36). Compared to API males in *upper middle-class suburbs,* API males residing in *suburban pioneer* neighborhoods had a slightly increased risk of death (HR = 1.09, 95% CI = 1.02 to 1.18), and those residing in *Hispanic small town* and *inner city* neighborhoods had a moderately increased risk of death with HRs of 1.31 (95% CI = 1.16 to 1.49) and 1.29 (95% CI = 1.18 to 1.40), respectively.

General patterns of prostate cancer-specific survival differ somewhat from that observed for overall survival; nSES seems less of a distinguishing feature of disparities in prostate cancer-specific survival by neighborhood archetype. For example, among NH Black males, relative risk of death is similar, compared to NH Black males in *upper middle-class suburbs*, among males of *rural/micropolitan*, *mixed SES-class suburb*, *Hispanic small town*, and *inner city* neighborhoods, despite these neighborhoods

Table 1. Distribution of demographic and tumor characteristics for prostate cancer cases according to 9-class neighborhood archetypes, California 1996-2005

		9-class Neighborhood Archetype								
	Total	Upper-middle class suburb	High status	New Urban/ Pedestrian	Mixed SES-class suburb	Rural/ Micropolitan	Suburban pioneer	City pioneer	Hispanic small town	Inner City
Total (*n*)	185,613	27,573	33,530	24,790	13,486	19,706	16,165	16,674	15,414	18,198
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Race/Ethnicity										
NH White	68.8	74.2	89.5	76.0	76.1	89.4	46.7	55.1	56.8	26.9
NH Black	9.5	5.3	2.7	7.7	8.0	2.5	11.2	18.0	12.9	27.2
Hispanic	13.2	7.3	4.0	6.6	10.8	5.1	24.3	14.9	25.8	37.1
API	6.8	11.3	2.1	7.8	3.4	1.1	16.3	10.3	3.0	7.3
Other	1.7	1.9	1.6	2.0	1.7	2.0	1.5	1.7	1.6	1.5
Marital status										
Single	8.9	5.5	6.3	14.5	5.6	6.6	7.6	14.5	7.4	13.5
Married	70.8	79.9	77.6	63.4	76.9	71.5	72.6	58.8	69.1	60.2
Separated/Divorced/ Widowed	13.3	9.1	10.4	15.3	10.6	14.2	13.1	18.8	14.8	17.5
Unknown	7.0	5.5	5.7	6.8	6.9	7.7	6.7	7.8	8.8	8.8
Age at diagnosis										
0 – 34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35 – 44	0.5	0.5	0.3	0.5	0.7	0.2	0.5	0.4	0.5	0.5
45 – 54	7.7	8.9	7.2	8.1	10.0	5.7	8.0	7.5	6.5	7.4
55 – 64	27.2	31.8	27.9	27.2	30.5	23.0	26.8	24.8	24.5	25.7
65 – 79	52.9	50.0	52.5	51.1	49.8	56.7	53.8	53.8	55.4	54.5
80+	11.8	8.7	12.0	12.9	9.0	14.4	10.8	13.4	13.0	11.9
Year of diagnosis										
1996	8.9	8.3	9.0	9.6	7.5	9.2	8.9	9.5	8.8	8.9
1997	9.3	8.9	9.6	9.6	8.0	9.6	9.5	9.9	9.3	9.0
1998	9.4	9.0	9.6	9.8	8.1	9.9	9.6	9.7	8.9	9.8
1999	10.1	10.0	10.1	10.2	9.6	10.1	10.1	10.1	10.2	10.1
2000	10.1	9.7	10.4	10.1	9.7	10.1	10.1	10.5	9.9	10.0
2001	10.4	10.5	10.6	10.6	10.6	10.2	10.3	10.1	10.5	10.3
2002	10.8	11.2	10.6	10.7	11.6	10.8	10.8	10.2	10.9	10.9
2003	10.2	10.7	10.1	9.6	11.4	9.8	10.0	10.3	10.3	10.2
2004	10.8	11.5	10.8	10.3	12.0	10.2	10.8	9.9	10.8	10.8
2005	9.9	10.2	9.2	9.5	11.5	10.1	10.0	9.7	10.3	10.0
SEER summary stage										
Localized	81.0	83.4	83.3	81.7	80.8	80.9	79.8	78.9	79.4	76.3
Regional	9.1	9.4	9.3	9.3	10.3	8.2	9.3	8.7	8.8	9.0
Distant	5.0	3.9	3.9	4.7	4.3	4.5	5.7	6.2	6.0	7.1
Unknown	5.0	3.2	3.6	4.3	4.6	6.5	5.2	6.2	5.8	7.5
Grade[a,b]										
I	4.7	4.2	4.2	4.4	4.1	5.4	5.0	4.9	5.5	5.4
II	63.7	66.2	66.3	64.2	65.5	60.3	62.5	61.6	61.4	61.1
III	25.7	25.2	24.3	25.7	24.4	27.2	26.3	26.6	25.9	26.6
Unknown	6.0	4.5	5.2	5.6	6.0	7.0	6.2	6.9	7.2	6.8

Continued

Table 1. Continued

		9-class Neighborhood Archetype								
	Total	Upper-middle class suburb	High status	New Urban/ Pedestrian	Mixed SES-class suburb	Rural/ Micropolitan	Suburban pioneer	City pioneer	Hispanic small town	Inner City
Surgery										
No surgery	60.2	57.2	58.0	60.8	56.8	63.0	60.6	63.9	61.1	62.7
Local tumor destruction	7.0	4.9	6.1	6.5	5.9	8.5	6.8	8.5	9.0	8.6
Prostatectomy	32.5	37.7	35.6	32.5	36.9	27.9	32.2	27.2	29.4	28.3
Unknown	0.4	0.2	0.3	0.2	0.4	0.6	0.3	0.4	0.6	0.5
Chemotherapy										
No	98.9	99.0	99.0	99.1	98.9	98.6	99.1	98.9	98.6	98.8
Yes	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.7	0.8
Unknown	0.5	0.3	0.4	0.3	0.5	0.8	0.4	0.5	0.7	0.5
Radiation										
No	66.4	64.4	64.9	67.0	65.7	63.0	67.4	67.6	67.1	72.4
Yes	33.6	35.6	35.1	33.0	34.2	36.8	32.5	32.3	32.8	27.5
Unknown	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1

[a] NH, Non-Hispanic; API, Asian/Pacific Islander; IBC, Inflammatory breast cancer; ER, estrogen receptor; PR, progesterone receptor.
[b] Grade I: Grade I or well differentiated; Grade II: Grade II or moderately well differentiated; Grade III: Grade III, Grade IV or poorly differentiated/undifferentiated/ anaplastic.

ranging from middle to low nSES. A similar pattern was seen for API males of *suburban pioneer* neighborhoods.

Racial/Ethnic Disparities Among Neighborhood Archetypes

We also examined whether neighborhood archetypes accounted for racial/ethnic disparities in survival among males with prostate cancer (Table 2). Sequential models indicate that accounting for neighborhood archetypes attenuated, but did not alleviate disparities in survival for NH Black males compared to NH White males (HR = 1.11, 95% CI = 1.09 to 1.13 and HR = 1.11, 95% CI = 1.06 to 1.16 for overall and prostate cancer-specific survival in the full model, respectively). Furthermore, models examining race/ethnicity-survival associations that are stratified by neighborhood archetype (Table 3) show that greater overall risk of death for NH Black males was observed specifically among residents of *upper middle-class, high status, mixed SES-class suburb*, and *suburban pioneer* neighborhoods that are either characterized by high composition of White residents or higher nSES.

DISCUSSION

We have shown disparities in prostate cancer survival according to neighborhood archetypes developed for California Census tracts. Overall and prostate cancer-specific survival differed by neighborhood archetypes, and patterns of these associations differed somewhat by race/ethnicity. The benefit of utilizing neighborhood archetypes is the ability to observe interactions among a large combination of measures representing several domains of neighborhood social and built environments. This allows for a more nuanced understanding of the potential impact neighborhoods have on survival since they represent the reality of neighborhoods and the multitude of social and built environment domains within.[15–19] Given a recent report showing widening socioeconomic and geographic disparities in cancer mortality in the U.S., this study is especially timely.[23]

While our results show varying patterns of associations between neighborhood archetypes and survival after prostate cancer diagnosis with some heterogeneity by race/ethnicity, some generalizations across race/ethnicity are apparent. For each racial/ethnic group, *inner city* and *Hispanic small town* neighborhoods are associated with the greatest risk of death, compared to *upper-middle class suburb* neighborhoods. While *Hispanic small town* and *inner city* neighborhoods are distinct from one another, they differ from other neighborhood types in being enclaves for Hispanic or Black residents (rather than a NH White or more diverse demographic), and unhealthy food. The coexistence of these neighborhood features and the association of these two archetypes with higher risk of death for all groups defined by race/ethnicity suggests that the confluence of racial residential segregation (and its known relationship with neighborhood socioeconomic disinvestment) with an unhealthy food environment defines a set of environmental conditions particularly harmful to prostate cancer survival.

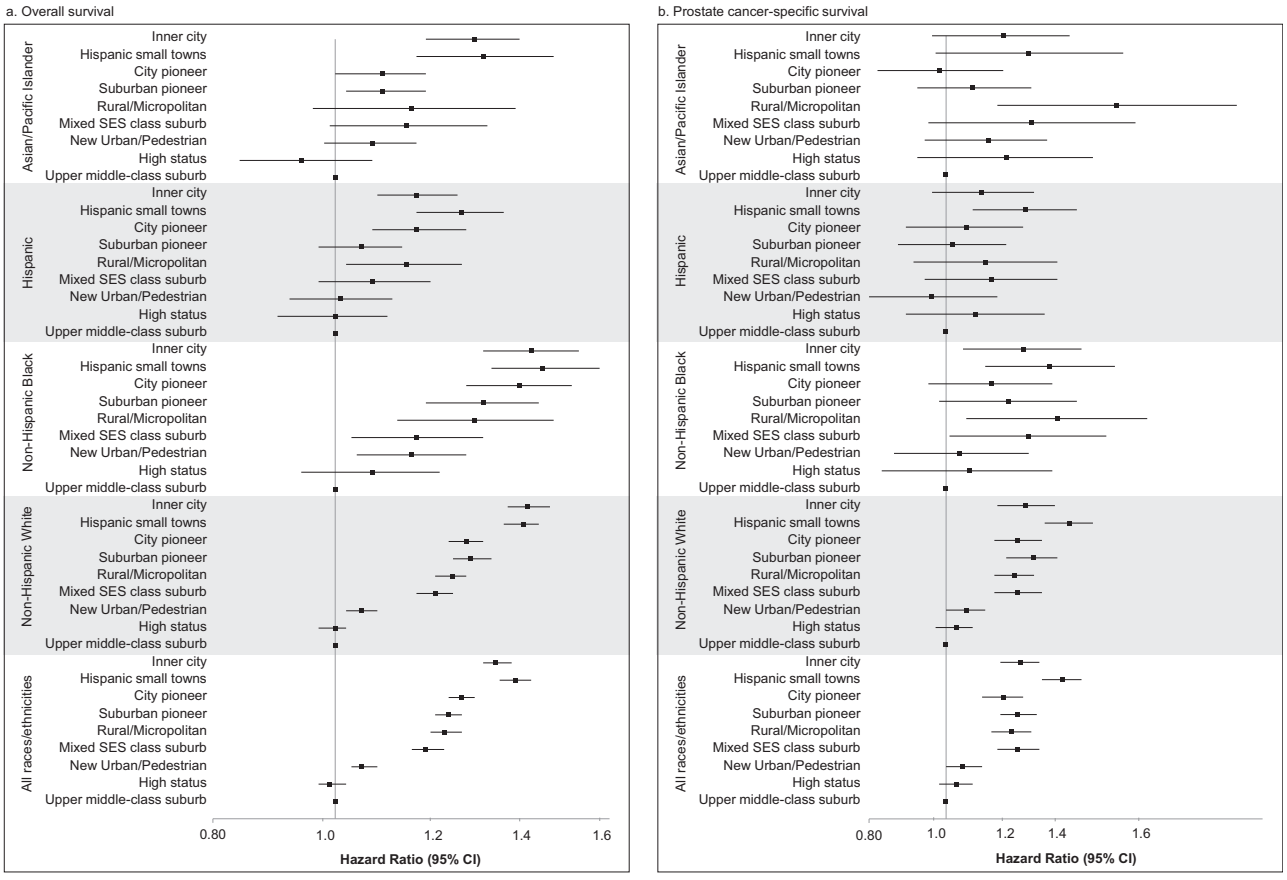

Figure 1. Disparities in prostate cancer survival according to neighborhood archetypes. Hazard ratios (HRs, black circles) and 95% confidence intervals (CIs, black horizontal lines) for (**A**) overall survival and (**B**) prostate cancer-specific survival according to 9-class archetypes among non-Hispanic (NH) White, NH African American, Hispanic, and Asian/Pacific Islander (API) men diagnosed with prostate cancer, California 1996-2005. The Upper middle-class suburb archetype serves as the reference category (HR, 1.00). This fully adjusted model includes age at diagnosis, year of diagnosis, SEER summary stage, grade, chemotherapy, radiation, surgery, marital status and cluster effect by census tract.

Nevertheless, our results also illustrate that the impact of neighborhood environments differ according to race/ethnicity. Among NH White males, some neighborhoods with greater risk of death, compared to *upper middle-class suburb* neighborhoods, had lower nSES while others are distinguished further by a diverse demographic, rural status, less greenspace, or unhealthy food. For NH Black males, neighborhoods with increased risk of death are distinguished by having more single-headed households, rental or vacant housing units, and unhealthy food outlets. For Hispanic males, the most prominent factors are lower nSES and unhealthy food. For API males, nSES is much less prominent, while rural/urban status and demographics appear to be stronger drivers. Such observations should help to focus multilevel interventions—interventions that extend beyond the individual to acknowledge and address how health disparities are perpetuated by factors at the interpersonal, neighborhood, and societal levels.[24,25] For example, our study highlights the potential benefit of housing security within *inner city* neighborhoods, particularly among NH Black residents. In response, interventions to address low prostate cancer survival among Black males (eg around diet, exercise, healthcare access), particularly for those who reside in *inner city* neighborhoods, may fall short at a population level without increased attention to housing security. Thus, to further inform multilevel interventions, it is important to assess interactions between other individual sociodemographic characteristics (eg nativity, education, occupation, gender, insurance status) and neighborhood archetypes in future studies. In this study, characteristics of individual-level SES were not available.

Prostate cancer survival outcomes among NH Black males are of particular interest, given highly documented disparities.[7,9,12,26–28] A previous multilevel case-only study of males with prostate cancer in the San Francisco Bay Area and Los Angeles County reported that nSES attenuated (but did not alleviate) greater risk of death for NH Black males.[9] The present study further shows that neighborhood archetypes likewise do not fully account for this racial/ethnic survival disparity. Furthermore, persistent prostate cancer-specific survival disparities for NH Black males residing in predominantly White and non-Hispanic or higher SES neighborhoods, allude to the potential influence of racial/ethnic residential segregation and discrimination in this survival disparity.[29–33]

Table 2. Hazard ratios and 95% confidence intervals for sequential models of overall and prostate cancer-specific survival according to race/ethnicity among men diagnosed with prostate cancer, California 1996-2005[a]

	Cases		Deaths		Base model[b]	Base model + Treatment[c]	Base model + Archetypes[d,e]
	n	Person-years	*n*	Person-years	HR (95% CI)	HR (95% CI)	HR (95% CI)
Overall survival							
All	185,613	2,090,810	105,155	867,171			
Race/ethnicity							
NH White	127,636	1,448,640	73,842	615,853	1.00 reference	1.00 reference	1.00 reference
NH Black	17,578	189,705	10,402	80,853	1.27 (1.24, 1.30)	1.22 (1.19, 1.24)	**1.11 (1.09, 1.13)**
Hispanic	24,582	272,890	13,146	106,556	0.95 (0.93, 0.97)	0.94 (0.92, 0.96)	**0.85 (0.83, 0.87)**
API	12,594	142,312	6,667	56,210	0.79 (0.77, 0.81)	0.78 (0.76, 0.80)	**0.75 (0.74, 0.77)**
Other	3,223	37,263	1,098	7,699	0.60 (0.56, 0.64)	0.54 (0.51, 0.57)	**0.53 (0.50, 0.56)**
Prostate cancer-specific survival							
All	185,613	2,090,810	23,975	155,461			
Race/ethnicity							
NH White	127,636	1,448,640	16,256	106,056	1.00 reference	1.00 reference	1.00 reference
NH Black	17,578	189,705	2,765	17,401	1.23 (1.18, 1.28)	1.18 (1.13, 1.22)	**1.11 (1.06, 1.16)**
Hispanic	24,582	272,890	3,394	21,882	1.00 (0.96, 1.04)	0.97 (0.94, 1.01)	**0.91 (0.87, 0.94)**
API	12,594	142,312	1,391	9,130	0.70 (0.66, 0.74)	0.68 (0.64, 0.72)	**0.68 (0.64, 0.71)**
Other	3,223	37,263	169	992	0.45 (0.39, 0.52)	0.39 (0.33, 0.45)	**0.39 (0.33, 0.45)**

[a] HR, Hazard Ratio; CI, Confidence interval; NH, Non-Hispanic.
[b] Model adjusted for age at diagnosis, year of diagnosis, and SEER summary stage.
[c] Model adjusted for age at diagnosis, year of diagnosis, SEER summary stage, marital status, grade, chemotherapy, radiation, and surgery.
[d] Model adjusted for age at diagnosis, year of diagnosis, SEER summary stage, marital status, grade, chemotherapy, radiation, surgery, census tract-level 9-class archetype and cluster effect by census tract.
[e] Bold type indicates statistically significant estimates (ie 95% CI does not include 1.0).

Studying neighborhood archetypes in the context of other cancer types will allow assessment of their relevance across sites and of how sex may modify the association of neighborhood archetypes with survival. We have also described associations of neighborhood archetypes with survival among females with breast cancer.[21] Like with prostate cancer, breast cancer survival according to neighborhood archetypes demonstrated some variation by race/ethnicity.[21] Future studies will assess whether patterns of association differ across sex within the context of non-sex-specific cancer types.

Our study examining prostate cancer survival according to neighborhood archetypes highlights the synergistic impact of multiple neighborhood domains on prostate cancer survival and emphasizes that neighborhood effects on cancer survival are modified by individual race/ethnicity. While we have information on individual race/ethnicity, the racial/ethnic categorizations available likely mask heterogeneity among these groups regarding ethnicity, nation of birth, immigration status, and other factors that may modify associations of neighborhood of residence with prostate cancer survival. We did aim to assess associations between neighborhood archetypes and survival among API and Hispanic males according to nativity, but low frequencies of cases among strata were insufficient to report on these analyses. Cancer registry data on individuals' detailed ethnicities for the diagnosis years included in this analysis are available, but low case frequencies prevented analysis of survival. In addition, other individual-level factors may modify the associations we observe, such as insurance status (not sufficiently available for diagnoses before 2001) and individual-level measures of SES (not available). While we included information on receipt of surgery, radiation, and chemotherapy in our analysis; information on active surveillance is not available from the registry for the time period of our analysis (diagnoses 1996-2005) and rates of active surveillance in the diagnosis years examined were low, so we could not assess whether the disparities we observe are independent of receipt of active surveillance.

While the archetype approach represents meaningful progress in population-level studies of the neighborhood environment some limitations should be addressed in future studies. We might expect other neighborhood domains, particularly access to healthcare resources,[34–36] to mediate some of the associations we observe and should be considered in the context of these archetypes where possible. Moreover, neighborhood features such as unhealthy food and lack of greenspace may be expected to be mediated by neighborhood health behavior norms and ultimately individual health behaviors, which should be considered in future studies. The 39 measures of neighborhood social and built environments consist of secondary data; we thus do not have information on the quality of neighborhood resources and features. Cancer registry data include only address at diagnosis; it will be important to assess whether residential mobility and neighborhood change impacts survival. Finally, the archetypes we have developed are available for California; this was the geography for which the secondary neighborhood data on specific neighborhood social and built environment factors were available, so our archetypes may not be directly applicable to other regions or the country. A similar approach

Table 3. Hazard ratios and 95% confidence intervals for overall and prostate cancer-specific survival according to race/ethnicity among men diagnosed with prostate cancer, stratified by each 9-class neighborhood archetype, California 1996-2005[a]

	Overall survival		Prostate cancer-specific survival	
	Minimally-adjusted model[b] HR 95% CI	Fully-adjusted model[c] HR 95% CI	Minimally-adjusted model[b] HR 95% CI	Fully-adjusted model[c,d] HR 95% CI
All archetypes combined				
NH White	1.00	1.00	1.00	1.00
NH Black	1.33 (1.30, 1.35)	1.22 (1.19, 1.24)	1.28 (1.22, 1.33)	**1.17 (1.13, 1.22)**
Hispanic	0.96 (0.94, 0.98)	0.94 (0.92, 0.96)	1.01 (0.98, 1.05)	0.97 (0.94, 1.01)
API	0.79 (0.77, 0.81)	0.78 (0.76, 0.80)	0.72 (0.68, 0.76)	**0.68 (0.64, 0.72)**
Upper middle-class suburb				
NH White	1.00	1.00	1.00	1.00
NH Black	1.19 (1.10, 1.30)	1.14 (1.04, 1.23)	1.29 (1.09, 1.52)	**1.21 (1.02, 1.42)**
Hispanic	0.99 (0.92, 1.06)	0.97 (0.91, 1.04)	1.12 (0.98, 1.28)	1.04 (0.91, 1.20)
API	0.83 (0.79, 0.88)	0.81 (0.76, 0.85)	0.78 (0.68, 0.88)	**0.70 (0.62, 0.79)**
High status				
NH White	1.00	1.00	1.00	1.00
NH Black	1.23 (1.11, 1.35)	1.17 (1.07, 1.29)	1.30 (1.07, 1.57)	**1.23 (1.02, 1.49)**
Hispanic	0.98 (0.90, 1.06)	0.97 (0.89, 1.05)	1.12 (0.96, 1.31)	1.09 (0.94, 1.28)
API	0.81 (0.73, 0.90)	0.77 (0.69, 0.86)	0.90 (0.72, 1.14)	0.83 (0.66, 1.04)
New urban/ Pedestrian				
NH White	1.00	1.00	1.00	1.00
NH Black	1.24 (1.17, 1.32)	1.16 (1.09, 1.24)	1.20 (1.06, 1.36)	1.11 (0.98, 1.26)
Hispanic	0.94 (0.88, 1.01)	0.92 (0.86, 0.99)	0.97 (0.84, 1.12)	0.92 (0.80, 1.06)
API	0.81 (0.76, 0.86)	0.82 (0.77, 0.87)	0.80 (0.70, 0.91)	**0.75 (0.65, 0.85)**
Mixed SES-class suburb				
NH White	1.00	1.00	1.00	1.00
NH Black	1.10 (1.00, 1.21)	1.06 (0.96, 1.16)	1.23 (1.04, 1.47)	**1.20 (1.01, 1.43)**
Hispanic	0.90 (0.84, 0.98)	0.85 (0.78, 0.92)	1.08 (0.93, 1.25)	0.95 (0.82, 1.11)
API	0.79 (0.69, 0.90)	0.77 (0.67, 0.88)	0.75 (0.57, 1.00)	**0.73 (0.55, 0.96)**
Rural/ Micropolitan				
NH White	1.00	1.00	1.00	1.00
NH Black	1.11 (1.04, 1.19)	1.06 (0.99, 1.13)	1.11 (0.97, 1.27)	1.02 (0.89, 1.17)
Hispanic	0.76 (0.72, 0.80)	0.77 (0.73, 0.81)	0.77 (0.69, 0.86)	**0.78 (0.70, 0.87)**
API	0.69 (0.65, 0.74)	0.69 (0.65, 0.74)	0.62 (0.55, 0.71)	**0.60 (0.53, 0.69)**
Suburban pioneer				
NH White	1.00	1.00	1.00	1.00
NH Black	1.20 (1.06, 1.35)	1.11 (0.98, 1.25)	1.43 (1.16, 1.78)	**1.30 (1.05, 1.61)**
Hispanic	0.88 (0.81, 0.96)	0.87 (0.80, 0.94)	0.99 (0.83, 1.17)	0.93 (0.78, 1.10)
API	0.79 (0.66, 0.94)	0.75 (0.63, 0.90)	1.03 (0.75, 1.43)	0.95 (0.68, 1.31)
City pioneer				
NH White	1.00	1.00	1.00	1.00
NH Black	1.19 (1.13, 1.25)	1.12 (1.07, 1.18)	1.08 (0.98, 1.20)	1.03 (0.93, 1.14)
Hispanic	0.84 (0.79, 0.89)	0.87 (0.82, 0.92)	0.84 (0.75, 0.95)	**0.87 (0.77, 0.98)**
API	0.70 (0.65, 0.74)	0.71 (0.66, 0.76)	0.59 (0.50, 0.68)	**0.58 (0.50, 0.67)**
Hispanic small town				
NH White	1.00	1.00	1.00	1.00
NH Black	1.13 (1.06, 1.20)	1.06 (1.00, 1.13)	1.13 (1.00, 1.27)	1.04 (0.93, 1.18)
Hispanic	0.85 (0.81, 0.89)	0.84 (0.80, 0.88)	0.91 (0.83, 1.00)	**0.89 (0.81, 0.98)**
API	0.79 (0.70, 0.88)	0.76 (0.68, 0.85)	0.67 (0.52, 0.86)	**0.66 (0.51, 0.84)**
Inner city				
NH White	1.00	1.00	1.00	1.00
NH Black	1.07 (1.02, 1.13)	1.02 (0.97, 1.07)	1.08 (0.98, 1.20)	1.07 (0.97, 1.18)
Hispanic	0.75 (0.72, 0.79)	0.77 (0.73, 0.81)	0.85 (0.77, 0.93)	**0.85 (0.77, 0.94)**
API	0.71 (0.66, 0.77)	0.74 (0.68, 0.80)	0.61 (0.51, 0.73)	**0.63 (0.53, 0.75)**

[a] HR, Hazard Ratio; CI, Confidence interval; NH, Non-Hispanic.
[b] Adjusted for age at diagnosis, year of diagnosis, SEER summary stage, and cluster effect by census tract.
[c] Adjusted for age at diagnosis, year of diagnosis, SEER summary stage, grade, chemotherapy, radiation, surgery, marital status and cluster effect by census tract.
[d] Bold type indicates statistically significant estimates (ie 95% CI does not include 1.0).

was previously used to develop national census tract-level archetypes but was not used to assess a health outcome.[37] With our illustration of the utility of neighborhood archetypes to examine place-based cancer health disparities, the approach should be repeated in other geographies (ie other states and regions, and nationally), with other health outcomes, and with more recent data, as appropriate.

This study illustrates the utility of neighborhood archetypes in describing disparities in prostate cancer survival beyond previously studied domains (ie nSES) and while accounting for complex interactions across several domains. Results highlight modifiable neighborhood domains most salient to survival among racial/ethnic groups, which may inform how and where interventions aimed at survival might be best applied.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2021.05.085.

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EDITORIAL COMMENT

Historical and contemporary data consistently show Black men have a higher incidence of prostate cancer and experience worse oncologic outcomes.[1] While the precise cause of these disparities remains unclear, a growing number of publications indicate that socioeconomic status (SES) and environmental exposures, also referred to as social determinants of health (SDOH), are substantial drivers of these differences. In this article, DeRouen et al. examine the relationship between neighborhood archetypes and racial/ethnic disparities seen in prostate cancer-specific mortality (PCSM) and overall survival (OS).[2] Using geocoded cancer registry data, prostate cancer patients were classified by a 9-class neighborhood archetype system that accounts for 39 measures of SES. The findings revealed that enclaves of Black and Hispanic residents lived in neighborhoods that generally had unhealthy food environments, which also correlated with higher rates of PCSM and OS. Additionally, there was a trend across all races showing as SES increased, outcomes improved. These results demonstrate a microcosm for the interaction of SDOH and health disparities that we know exist in society.

A prominent example of such interaction is seen in the current COVID-19 pandemic. The intersection of poverty, oppression, and health disparities is striking as Black, Hispanic, and Indigenous communities are more likely to contract and die from COVID-19.[3] As seen in COVID-19, these structural factors impact SDOH, including, but not limited to, access to care, healthcare outcomes, and patient/physician trust. Specifically, research demonstrates that prostate cancer-specific mortality is increased in those patients experiencing reduced access to healthcare, regardless of race.[4] But when care is received in an equal access setting (VA Health System and clinical trials), Dess et al. revealed black men had no difference in PCSM compared to other races.[5] Yet still, this article found that survival disparities persist for Black men despite residing in higher SES neighborhoods.[2] These findings illustrate that despite financial progress, there remain factors related to structural and potentially interpersonal racism that influence health outcomes.

This study's findings highlight the necessity to view health disparities through a multifactorial lens. While archetypes do not capture every detail at the individual level, they provide a broad understanding of the trends across races. Thus, developing and analyzing archetypes across the country may prove helpful. As the authors astutely recognized, multiple factors influence differences in outcomes between races; therefore, a multi-pronged solution is necessary. Potential initial steps include community-based surveying to clearly define the needs of Black, Hispanic, Indigenous, and low SES communities. Concurrently, as we aim to enhance education and raise awareness about prostate cancer screening, diagnosis, and treatment, there needs to be purposeful allocation of financial resources and diversification of the medical field. The goal is to design a system that ameliorates the systematic injustices that result in food deserts, low health literacy, and decreased access to care. While these solutions require large-scale changes, including policy overhauls, as a field, we have a responsibility to advocate for change while being cognizant of our individual biases that negatively impact patient outcomes.

Brandee Branche, Peace Orji, Randy Vince,
Department of Urology, University of Michigan, Ann Arbor MI; Case Western Reserve University School of Medicine, Cleveland OH

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