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Research Article

Neighborhood Factors Associated with Time to Resolution Following an Abnormal Breast or Cervical Cancer Screening Test

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Abstract

Background: The effect of neighborhood and healthcare access factors on cancer outcomes among patients enrolled in navigator programs is not clearly understood. This study assessed associations between: (i) neighborhood factors and diagnostic time to resolution (TTR) and (ii) geographic access and TTR following an abnormal breast or cervical cancer screening test among women participating in the Ohio Patient Navigator Research Program (OPNRP).

Methods: Patient (demographic, socioeconomic status, home-to-clinic distance) and neighborhood (deprivation, racial segregation) characteristics of 801 women living in one of 285 census tracts (CT) in greater Columbus, Ohio were examined. Randomization to receive navigation occurred at the clinic level. Multilevel Cox regression and spatial analysis were used to estimate effects of various factors on TTR and assess model assumptions, respectively.

Results: TTR increased as neighborhood deprivation increased. After adjustment for age, friend social support, education, and healthcare status, the TTR among women living in a neighborhood with a moderate median household income (between \$36,147 and \$53,099) was shorter compared with women living in low median household income neighborhoods (<\$36,147; $P < 0.05$). There is little evidence that unmeasured confounders are geographically patterned.

Conclusions: Increased neighborhood socioeconomic deprivation was associated with longer TTR following an abnormal breast or cervical cancer screening test.

Impact: These results highlight the need for addressing patient- and neighborhood-level factors to reduce cancer disparities among underserved populations. *Cancer Epidemiol Biomarkers Prev; 23(12); 2819–28. ©2014 AACR.*

Introduction

Minority and socioeconomically disadvantaged populations are more likely to be diagnosed with late-stage disease and subsequently have elevated rates of cancer mortality compared with white, higher socioeconomic status (SES) populations (1–6). Minorities and those of lower SES are also less likely to access and utilize high quality and timely medical services, including within-guidelines cancer screening and follow-up tests (7, 8) known to improve cancer outcomes (9). However, these disparities are not well understood. Recent studies suggest barriers to receiving appropriate cancer care at the patient- (e.g., SES, medical mistrust, inadequate transportation), provider- (e.g., sociocultural competence, training), and healthcare system level (e.g., insurance acceptance; refs. 10–12) may be important among underserved groups. In addition, residential neighborhood characteristics (e.g., socioeconomic conditions, racial segregation) may be related to patient-level cancer screening and outcome disparities (13–16).

Studies indicate the potential benefit of patient navigation (PN) interventions to reducing cancer disparities. By addressing multilevel barriers, PN promotes increased screening rates and reduced delays to receipt of cancer care services, including appropriate follow-up and treatment following abnormal tests (reviewed by Paskett and colleagues; ref. 17). Data support the efficacy of PN in reducing time to diagnostic resolution (herein referred to as TTR) after abnormal screening tests for breast and cervical cancers (18–21).

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Previous PN studies explored the relationship between the postal service-based, zip code-level measure of median household income or percentage below the federal poverty level (FPL) and various cancer outcomes (18, 22, 23). Two studies reported statistically insignificant associations (22, 23), whereas the other did not report their findings (18). Neighborhood research suggests that: (i) census tracts (CT) approximate neighborhoods better than zip codes and (ii) measures of several neighborhood constructs (e.g., racial segregation, neighborhood socioeconomic deprivation) should be considered when investigating the effects of neighborhood factors on cancer outcomes (24, 25).

Little attention has been given to geographic measures of healthcare access that may affect cancer outcomes within PN studies. The one known PN study investigating the effects of home-to-treatment facility distance on a cancer outcome did not report on the association with time to treatment initiation (22). Though results are mixed, longer travel time or home-to-healthcare facility distance may increase the odds of late-stage cancer diagnosis (26–29). Given the frequency in which PN program participants report transportation barriers (30, 31), closer examination of the effects that geographic access may have on cancer outcomes within PN studies is needed.

Because the effects of neighborhood factors and geographic access on cancer outcomes within PN studies have yet to be fully investigated, the primary aim of this analysis was to determine whether neighborhood factors and geographic healthcare access are significantly associated with TTR following an abnormal breast or cervical cancer screening test among participants of the Ohio Patient Navigator Research Program (OPNRP). We hypothesized that TTR would increase with: (i) increasing neighborhood socioeconomic deprivation; (ii) increased racial segregation; and (iii) increased home-to-clinic distance.

Materials and Methods

Study design

The OPNRP was a group randomized trial described in detail elsewhere (21, 32). Briefly, health clinics in greater Columbus, Ohio were randomized to the PN intervention or usual care condition. Participants met eligibility criteria if they were: a regular patient of an enrolled clinic; identified as testing positive for an abnormal breast, cervical, or colon cancer screening test, an abnormal diagnostic test, or an abnormal clinical finding; older than 18 years of age; not cognitively impaired; able to provide informed consent; without a prior history of cancer; not living in institutional care; without a prior history of PN; and able to speak or understand English or Spanish. Because of a small number of abnormal colon cancer tests, this paper focuses on women with breast and cervical abnormalities. A breast cancer screening abnormality was a breast mass, clinical finding suspicious for cancer, or breast imaging reporting and data system 0, 3, 4, 5. A cervical cancer screening abnormality was low- or high-grade squamous cell intraepithelial lesion, atypical cells of undetermined significance with or without positivity for human papillomavirus, or atypical granular cells of undetermined significance (32). Upon receipt of physician consent, potential participants were mailed a letter introducing the study, followed by a telephone call that provided an overview of the OPNRP and assessed their willingness to participate in the study. Those wishing to participate provided verbal consent and completed a baseline questionnaire during the telephone call or in-person at a location of their preference (21). Participants were enrolled between 2006 and 2010.

The PN intervention was administered by lay navigators via telephone according to the Ohio American Cancer Society model of PN (21). The navigators' primary goal was to identify and develop actions to eliminate barriers preventing participants from receiving follow-up care for an abnormal cancer screening test. Navigators also provided social (e.g., supportive listening, educational materials) and instrumental (i.e., negotiating logistical or financial barriers) support. Control clinic participants were mailed informational materials specific to their cancer screening test within one month of completing the baseline questionnaire (21). All participants completed a second questionnaire at one of the study's prespecified endpoints (i.e., diagnostic resolution of the abnormal screening or censoring at 365 days after follow-up).

Conceptual model

Extant theories, frameworks, and mechanistic pathways detail how and why neighborhood and healthcare access constructs may affect health outcomes (24, 33–37). Neighborhood deprivation is a measure of neighborhood-level resources derived from Census Bureau variables (i.e., percentage of residents within an administrative unit who: are unemployed, have incomes below the FPL, have less than a high school diploma, have less than a 4-year college degree; and median household income) that may indicate areas in which access to and utilization of diagnostic services are limited (38–40). Concentrated racial inequality or racial segregation may indicate areas of discrimination that delay or inhibit use of diagnostic services by individuals because of lacking financial resources or discriminatory practices (39, 41, 42). Healthcare access has been defined as a multidimensional construct, of which, geographic healthcare access (e.g., distance from residence to clinic) is part (43).

Previous research demonstrates how increased neighborhood levels of racial segregation and deprivation and decreased individual-level geographic healthcare access negatively impact cancer outcomes (13, 25, 39, 44). We are synthesizing and adapting existing research to test our hypotheses of associations with TTR following an abnormal breast or cervical cancer screening test. Important individual-level factors, which may partially mediate the relationship between several neighborhood and healthcare access factors and cancer outcomes and provide more

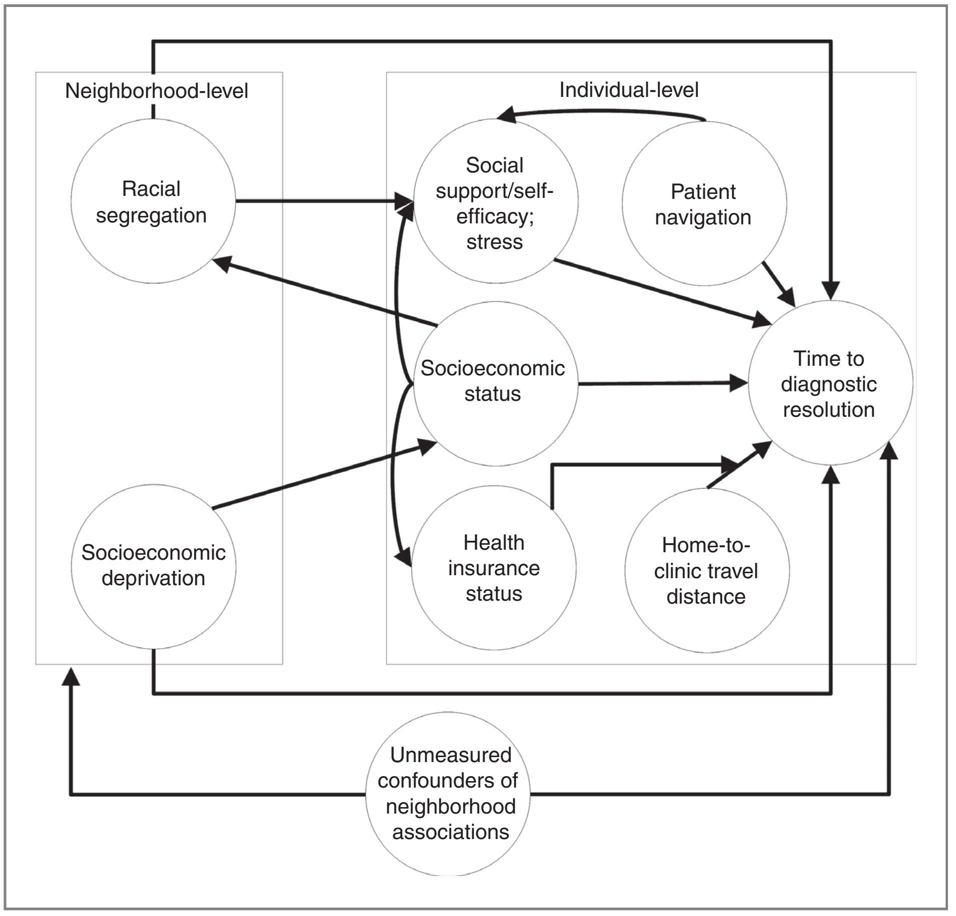

Figure 1. Conceptual model of relationships involving neighborhood deprivation, racial segregation, individual SES, healthcare access, and time to diagnostic resolution.

mechanistic explanation, are psychosocial stress, social support, self-efficacy, SES (education status, wealth), and health insurance status (24, 33–37). A model of these relationships is presented in Fig. 1.

Measures

TTR, the endpoint of our study, was determined by medical record review. Data from participants who did not reach diagnostic resolution by the end of follow-up (i.e., TTR greater than follow-up time) were treated as right censored. Diagnostic resolution was defined as, "...completion of the diagnostic test that results in a diagnosis or clinical evaluation that determines that no further evaluation is indicated." (32).

Patient-level demographic, healthcare, and socioeconomic characteristics were gathered from self-reported baseline and end-of-study questionnaires. Demographic data included age, race, marital status, and residential address. Healthcare status was indicated by health insurance type (e.g., public, private, uninsured). Socioeconomic data included employment status, educational attainment, and household income.

Patients' residential addresses were geocoded to the house level to calculate home-to-clinic road distance. CTs were used to approximate patients' neighborhoods (25, 39). The following neighborhood-level factors were gathered from the 2000 Census (45, 46): racial segregation (Gini coefficient; ref. 46) and measures of neighborhood deprivation (percentage of residents without a bachelor's degree, percentage of residents without a high school diploma, percentage of residents below the FPL, percentage of residents unemployed, and median household income). Here, the Gini coefficient measures the "unevenness" of the racial distribution found within a neighborhood. It ranges from 0 to 1 or no to total segregation (47). Gini coefficients of racial segregation, measured at the census place level (i.e., city or town), were attributed to CTs if the CTs shared a boundary with the place. Only the non-Hispanic, African American racial segregation index was considered because the majority of patients identified as African American or white. Healthcare geographic accessibility was measured by patient-level home-to-clinic distance.

Data analysis

There were 801 women with an abnormal breast or cervical cancer screening exam enrolled in the OPNRP. TTR, the primary outcome in the OPNRP, was originally analyzed by accounting for clustering of patients within clinics. Because the present analysis aimed to test the effects of neighborhood factors on TTR, we accounted for clustering of patients within CTs using Gamma

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distributed, CT effects, and adjusted for the clinic-level intervention using a stratified Cox model.

Neighborhood factors and home-to-clinic distance were analyzed in both continuous (i.e., Z-score) and tertile forms in anticipation of nonlinear relationships (40, 48, 49). The distributions of patient- and neighborhood-level factors were summarized by intervention arm, the factor by which participants were randomized.

A multiple predictor Cox regression model was built to assess the relationships between the above factors and TTR (50, 51). Individual-level measures of SES likely mediate the relationship between neighborhood-level social constructs and various health outcomes (42, 52, 53). Therefore, unadjusted HRs quantifying the relationship between neighborhood factors and TTR were first estimated. A HR greater than one indicates faster resolution or shorter TTR, relative to reference. Intervention arm was handled differently than other potential model covariates because it was measured at the clinic level and hence we could not model an intervention effect without the inclusion of a clinic-level random effect (54). To avoid this complication, we stratified our Cox model on intervention arm. Forward selection was used to build a stratified Cox model containing adjusted associations between neighborhood and geographic factors and TTR. The confounding effects of intervention arm on any statistically significant neighborhood and geographic factors of the final model were assessed by fitting the final model without stratification on intervention arm. Arm was not included in any additional analyses if there was less than a 10% change in HRs between models with and without control for intervention arm. The proportional hazards assumption of the final model was assessed through tests of statistical significance of interactions between each covariate and time (log transformed). After a main effects model was selected, theoretically motivated interactions were tested (i.e., race by African American segregation and health insurance status by home-to-clinic distance). P values less than 0.05 were considered statistically significant, and confidence intervals (CI) were also calculated.

Spatial autocorrelation analysis was used to partially assess model assumptions (i.e., independence conditional on the neighborhood and individual level factors in the Cox model and the random CT effects) and the presence of any geographic clustering of patient- or CT-level model residuals (longer or shorter resolution times; ref. 55). Describing the geographic pattern of model residuals can be helpful in identifying and controlling for bias in the form of unmeasured confounders (56, 57). The expectation was that, conditional on model estimates and censoring, the spatial distribution of TTR would be mixed throughout the study area. Moran's I was used to determine the presence of spatial autocorrelation in residuals of the final model (58, 59). Individual-level residuals were the deviance residuals, whereas neighborhood-level residuals were the CT-specific random intercepts. The sign of a Moran's I value indicates clustering (+) or dispersion (−), whereas the numerical magnitude, ranging from 0 to 1, indicates the degree of clustering or dispersion (59). In this case, positive Moran's I values indicate that longer (shorter) resolution times were within a closer proximity to one another than expected, whereas negative values indicate that longer and shorter resolution times are interspersed in a regular pattern (i.e., a checkerboard exhibits negative spatial autocorrelation; ref. 59). Statistically significant positive spatial autocorrelation would indicate that model assumptions are not met and estimates' SEs are artificially low (i.e., inflated type-1 error; ref. 55). Moran's I test statistics and P values were calculated under null hypotheses of random labeling ($N = 999$ Monte Carlo replicates). Various distance-based, spatial neighborhood matrix conceptualizations, required, user-defined inputs specifying how spatial autocorrelation is assessed, were used: 35 km, 29 km, and 20 km. Various spatial neighborhood conceptualizations were used to investigate the presence of unmeasured confounders that may operate on various spatial scales (57). Type-I error for all estimates was set at 0.05. Bonferroni adjustments were used in spatial autocorrelation analysis to account for multiple calculations of Moran's I using the various spatial neighborhood matrix conceptualizations (type-I error of 0.017). Analyses were conducted using Stata Intercooled (v. 13), ArcGIS (v. 10.2), and GeoDa (v. 1.4.6; refs. 58, 60, 61).

Results

Participants

A total of 801 patients from 285 CTs were included in the final analytic sample which included participants of both study arm and on which all results are based. The median age of patients was 44 years (Table 1). The majority were white (71%), 48% were college graduates, and 71% had private health insurance.

The average home-to-clinic distance was 8.9 miles but the distribution was positively skewed because of some individuals living far away from clinics. The average neighborhood median household income was $50,592, and those randomized to intervention clinics lived in areas of slightly higher neighborhood income and lower poverty than those of the comparison arm. Participants lived in areas segregated between African American and whites (average Gini index = 0.69).

Associations with time to diagnostic resolution

The unadjusted associations with TTR are provided in Table 2. TTR was shorter (i.e., HR greater than 1.0) among women who: were older ($P = 0.002$), more educated ($P < 0.05$ for all education levels relative to less than high school), or had private health insurance ($P < 0.05$ relative to uninsured). When treated categorically, all measures of neighborhood deprivation estimated were significantly associated with TTR (all $P < 0.02$); higher neighborhood deprivation was associated with longer TTR (HR less than 1.0). There were no statistically significant differences in TTR by home-to-clinic distance or

Table 1. Descriptive statistics of females enrolled in the OPNRP following an abnormal breast or cervical cancer screening test by intervention arm

Variable	Comparison clinics (N = 343) N/mean (%/SD)	Intervention clinics (N = 458) N/mean (%/SD)	Total (N = 801) N/mean (%/SD)
Individual level			
Age, y	42.7 (15)	45.8 (14.5)	44.5 (14.8)
Race			
White	239 (70.9)	329 (71.8)	568 (71.4)
African American	76 (22.6)	91 (19.9)	167 (21)
Other	22 (6.5)	38 (8.3)	60 (7.5)
Education level			
<High school	15 (4.4)	24 (5.2)	39 (4.9)
High school	34 (10.0)	73 (15.9)	107 (13.4)
Some college/associate's degree	126 (37.2)	144 (31.4)	270 (33.9)
College grad/graduate degree	164 (48.4)	217 (47.4)	381 (47.8)
Health insurance			
Private	239 (72.6)	313 (69.9)	552 (71)
Public	81 (24.6)	114 (25.4)	195 (25.1)
Uninsured	9 (2.7)	21 (4.7)	30 (3.9)
Stress level (STRM score)	21.4 (8.2)	21 (8.4)	21.2 (8.3)
Family support (PSS-Family)	15.9 (5.6)	16.1 (5.3)	16.0 (5.4)
Friend support (PSS friend)	16.8 (4.4)	16.7 (4.1)	16.7 (4.2)
Home-to-clinic distance (mi)	8.7 (12.0)	9.0 (10.2)	8.9 (11.0)
Neighborhood level			
Percent without a bachelor's degree	65.6 (21.4)	64.2 (20.3)	64.8 (20.1)
Percent without a high school diploma	13.6 (11.3)	12.1 (11.0)	12.8 (11.2)
Median household income	47,846 (20157)	52,660 (22624)	50,592 (21717)
Percent impoverished	8.6 (9.4)	7.4 (9.1)	7.9 (9.2)
Percent unemployed	4.2 (3.4)	3.9 (3.4)	4.0 (3.4)
African American segregation (Gini coefficient)	0.70 (0.12)	0.69 (0.14)	0.69 (0.13)

African American segregation when treated continuously or categorically (All $P > 0.45$, categorical data not shown). Tests for interaction between health insurance status and home-to-clinic distance, and race and African American segregation were not statistically significant ($P = 0.71$ and $P = 0.59$, respectfully; data not shown).

The final model, built using forward selection, included age, health insurance type, education status, friend social support, and neighborhood median household income (Table 3). After adjustment for education status, health insurance status, and friend social support, women living in neighborhoods with a median household income between \$36,147 and \$53,099 had a shorter TTR than women living in neighborhoods with median household incomes of less than \$36,147 (HR = 1.30, $P = 0.02$). TTR among women living in neighborhoods of the highest tertile of median household income (at least \$53,099) did not differ from women living in neighborhoods of the lowest tertile of median household income (less than \$36,147). There was little evidence that intervention arm confounded the association between median household income and TTR (arm-adjusted HR = 1.28, data not shown). Adjusting for the other factors in our final model (excluding arm), TTR was shorter among women who: were older ($P = 0.044$), had a higher education status ($P < 0.05$ compared with less than high school, except for women with some college or an associate's degree with $P = 0.052$), had private health insurance ($P < 0.05$ relative to uninsured), and with a PSS friend social support score of the highest tertile ($P < 0.05$ relative to lowest tertile).

Spatial characteristics

There was little evidence of spatial autocorrelation of individual- or CT-level residuals of the final model using the 20 km, 29 km, or 35 km spatial neighborhood conceptualizations (Moran's I < $\pm$ 0.004 $P > 0.052$; data not shown). This indicates that any unmeasured confounding variable(s) that may account for the final model associations with TTR was not spatially structured, conditional on the various spatial neighborhood conceptualizations used (56, 57).

Discussion

This study investigated the neighborhood-level effects of socioeconomic deprivation and racial segregation and

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Table 2. Unadjusted HRs of abnormal cancer screening resolution for patient- and neighborhood-level factors[a]

Variable	HR (95% CI)[b]	P^c
Individual level		
Age, y[d]	1.12 (1.04–1.21)	0.002
Education level		<0.001
≤High school	Referent	
High school	1.92 (1.24–2.97)	
Some college/associate's degree	1.55 (1.03–2.33)	
College grad/graduate degree	2.18 (1.46–3.25)	
Health insurance		<0.001
Uninsured	Referent	
Private	1.65 (1.10–2.5)	
Public	1.14 (0.74–1.76)	
Friend support (PSS friend)		0.001
<16 PSS friend score	Referent	
16 ≤ PSS friend score < 19	1.29 (1.03–1.60)	
≥19 PSS friend score	1.31 (1.08–1.60)	
Home-to-clinic distance (miles)		0.454
<4.00	Referent	
4.00 ≤distance <8.91	1.00 (0.83–1.20)	
> = 8.91	1.01 (0.84–1.22)	
Neighborhood level		
Percent without a bachelor's degree		<0.001
<59.5%	Referent	
59.5% ≤% bachelors < 84.5%	0.92 (0.78–1.09)	
≥84.5%	0.70 (0.58–0.85)	
Percent without a high school diploma		0.003
<7.6%	Referent	
7.6% ≤ % high school < 16.8%	0.92 (0.77–1.09)	
≥16.8%	0.73 (0.61–0.87)	
Median household income		<0.001
<$36,147	Referent	
$36,147 ≤ income < $53,099	1.47 (1.21–1.78)	
≥$53,099	1.34 (1.12–1.61)	
Percent below 100% FPL		0.008
<2.6%	Referent	
2.6% ≤ % < 100% FPL < 8.8%	0.99 (0.83–1.19)	
≥8.8%	0.77 (0.64–0.93)	
Percent unemployed		0.027
<2.5%	Referent	
2.5% ≤ % unemployed < 4.4%	0.84 (0.70–1.01)	
≥4.4%	0.78 (0.64–0.95)	
African American segregation (Gini coefficient)		0.761
<0.334	Referent	
0.334 ≤ Gini coefficient < 0.619	0.94 (0.47–1.87)	
≥0.619	0.90 (0.63–1.29)	

[a]The sample used to calculate these estimates includes participants of both study arms.
[b]HR = Hazard Ratio; 95% CI = 95% confidence interval.
[c]*P* value is for a χ^2 test of improved model fit with the addition of the variable.
[d]Hazard ratio is for a one standard deviation increase of age (14.8 years).

individual-level effects of geographic access on TTR following an abnormal breast or cervical cancer screening test among women enrolled in a PN intervention trial. The hypothesis that higher neighborhood-level racial segregation would be associated with longer TTR was not supported by our findings. There was also no evidence

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Table 3. Final model HRs of abnormal cancer screening resolution for patient- and neighborhood-level factors[a]

Variable	HR (95% CI)	P^b
Age, y[c]	1.09 (1.00–1.19)	0.044
Education level		0.004
≤High school	Referent	
High school	2.32 (1.32–4.07)	
Some college/associate's degree	1.71 (1.00–2.92)	
College grad/graduate degree	2.11 (1.22–3.66)	
Health insurance		0.003
Uninsured	Referent	
Private	1.68 (1.09–2.58)	
Public	1.24 (0.79–1.95)	
Friend support (PSS friend)		0.096
Low support (<16 PSS friend score)	Referent	
Moderate support (16 ≤ PSS friend score < 19	1.22 (0.98–1.52)	
High support (≥19 PSS friend score)	1.23 (1.01–1.50)	
Median household income		0.017
Low median household income (<$36,147)	Referent	
Moderate median household income ($36,147 ≤ Income < $53,099)	1.30 (1.05–1.61)	
High median household income (≥$53,099)	1.03 (0.83–1.28)	

[a]The sample used to calculate these estimates includes participants of both study arms.
[b]*P* value is for a χ^2 test of improved model fit with the addition of the variable.
[c]HR is for a one SD increase of age (14.8 years).

to support the hypothesis that TTR would increase with longer home-to-clinic distance. However, higher levels of neighborhood deprivation were associated with longer TTR. After adjustment for age, education status, health insurance status, and friend social support, residing in a neighborhood with a moderate (between $36,147 and $53,099) compared with low (<$36,147) median household income was associated with TTR. Together with the null results of spatial autocorrelation analyses, any unmeasured confounding variable that might have accounted for the association between median household income and TTR was independent of age, education status, health insurance status, and friend social support, as well as any factor that exhibits geographic patterns assessed using the spatial neighborhood conceptualizations (56, 57).

That median household income, the only measure of neighborhood deprivation found to be significant in the final model deserves some discussion. Prevailing theory, as depicted in our conceptual model, suggests that the relationship between neighborhood deprivation and TTR is partially mediated by individual SES (24, 62). If true, then adjustment for education status in our final model biased the association between neighborhood deprivation and TTR toward the null (63). The unadjusted and adjusted HRs comparing the levels of neighborhood deprivation may represent the lower and upper extremes of the true effects. It is also important to note that the high correlations (Pearson correlation coefficients, 0.43–0.79; results not shown) between neighborhood deprivation measures precluded any two measures from being simultaneously and accurately estimated in the same model. Mediation methods may be needed to further characterize the relationships between neighborhood deprivation, individual SES, and resolution rate (64, 65). The mechanisms behind the unexpected, nonlinear trend in the effect of median household income and TTR are not readily apparent. Further scrutiny of neighborhoods with moderate median household income may indicate factors that could account for this association (e.g., increased access to clinics). Investigations of the distributions of individual education status and various measures of neighborhood deprivation suggest that respective tertiles of each neighborhood deprivation measure contain nearly identical proportions of each education status (i.e., the number of those with less than a high school diploma is the same within the lowest tertile of each neighborhood deprivation measure, the number of those with a high school diploma is the same within the middle tertile of each neighborhood deprivation measure, etc.). This suggests that the neighborhood deprivation results of our final model (i.e., that median household income is the only measure of neighborhood deprivation found to be associated with TTR) are not due to differential confounding of individual level education on the various relationships between neighborhood deprivation and TTR.

Of the three existing studies examining the effects of any neighborhood deprivation metric on a cancer

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outcome among participants in a PN program (18, 22, 23), two reported insignificant associations (22, 23) and the other did not report the association (18). No other study has assessed the effects of CT-level measures of neighborhood deprivation, within a multilevel analytic framework or otherwise, among participants of a PN program. However, several studies have examined the effects of various CT-level deprivation measures on other cancer outcomes (66–69). In general, decreased CT-level deprivation is associated with favorable cancer screening, incidence, treatment, and mortality outcomes.

The lack of an association between distance from a patient's home to their clinic and TTR is not surprising but interesting. The only PN study to assess the relationship between receipt of treatment and home-to-clinic distance did not report on this association (22). Two studies of breast cancer stage at diagnosis have reported that increased travel time or distance to closest mammography facility was not associated with later stage at diagnosis (26, 27), whereas two other studies found that longer travel distance to the nearest facility was associated with increased odds of later stage at diagnosis among rural populations (28, 29). All four of these studies suffered from misclassification bias caused by the attribution of the nearest facility as the individual's actual provider, as well as the assumption that the shortest path between one's residence and the nearest facility is always taken. Conclusions about the association between home-to-clinic distance and cancer outcomes are further complicated by the finding that longer travel time from residence to actual diagnosing facility was significantly associated with decreased odds of later stage at breast cancer diagnosis, adjusting for age, race, ethnicity, neighborhood poverty, and rural status in one study (26). Only 6.8% of navigated patients enrolled in the OPNRP reported any transportation or clinic location barriers. Assuming that the patients randomized to clinics that did not receive PN experienced similarly low frequencies of transportation or clinic location barriers may help explain the lack of an association between home-to-clinic distance and TTR. It is possible that transportation barriers or distance to clinic had negligible effects on TTR among our study sample of predominately urban, highly educated, privately insured white women.

Similar to studies of travel distance, findings from previous studies examining associations between racial segregation indices and cancer outcomes are mixed (13, 16). Our finding of no association between neighborhood-level segregation and TTR was similar to a study which found no association between census place-level racial segregation and late-stage diagnosis of breast cancer (16). A study of women in Detroit, Michigan found that zip code-level African American segregation was significantly associated with late-stage diagnosis (13). The inconsistencies across studies are likely affected by the various geographic levels at which African American segregation was measured as well as by the cancer outcome investigated. These discrepancies suggest that future studies should assess the relationships between cancer outcomes and racial segregation measures on a smaller geographic scale (e.g., the CT level).

Strengths of this study include the use of a multilevel Cox model to account for patient- and neighborhood-level effects, the simultaneous investigation of several dimensions of neighborhood factors and geographic healthcare accessibility, and the use of spatial analysis to investigate unmeasured confounding. However, our findings may be limited by the sociodemographic composition of study participants (e.g., majority urban, white, highly educated, privately insured) and the undertaking of secondary analysis of data not powered to detect neighborhood-level effects.

These findings provide evidence of the presence of a relationship between measures of neighborhood deprivation and TTR following an abnormal cancer screening test and the lack of relationships between home-to-clinic distance and segregation factors and TTR following an abnormal cancer screening test among women enrolled in a PN trial. Our results support those of previous studies indicating a null association between place-level racial segregation and cancer outcomes, while suggesting the need to measure racial segregation at the CT level. The low frequency of patient-reported transportation barriers, high patient sociodemographic characteristics, and null association between distance to clinic and TTR suggest that our sample may be unique. Additional research is needed to clarify the association between home-to-clinic distance and cancer outcomes among lower SES urban and rural dwellers. Future research should also investigate relationships between SES, urban status, home-to-clinic distance, and cancer outcomes using patient-reported travel routes.

Thus far, the impact of neighborhood factors and geographic healthcare access on cancer outcomes among patients enrolled in PN programs has been largely untested. Evidence that measures of higher neighborhood-level deprivation are associated with longer TTR among participants enrolled in a PN trial necessitates replication and clarification of this relationship. If future work supports the significant associations found herein, targeting younger women of lower educational attainment, without health insurance who reside in neighborhoods of lower socioeconomic resources, may improve TTR following an abnormal breast or cervical cancer screening test in these underserved populations.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

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Neighborhood Factors Associated with Time to Resolution Following an Abnormal Breast or Cervical Cancer Screening Test

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