Racial Disparities in Breast Cancer Survival: The Mediating Effects of Macro-Social Context and Social Network Factors

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Ganga Vijayasiri , *University of Illinois at Chicago*, gvijay2@uic.edu
Yamile Molina , *University of Illinois at Chicago*
Ifeanyi B. Chukwudozie , *University of Illinois at Chicago*

See next page for additional authors

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Abstract

ABSTRACT

This study attempts to clarify the associations between macro-social and social network factors and continuing racial disparities in breast cancer survival. The study improves on prior methodologies by using a neighborhood disadvantage measure that assesses both economic and social disadvantage and an ego-network measurement tool that assesses key social network characteristics. Our population-based sample included 786 breast cancer patients (nHWhite=388; nHBlack=398) diagnosed during 2005-2008 in Chicago, IL. The data included census-derived macro-social context, self-reported social network, self-reported demographic and medically abstracted health measures. Mortality data from the National Death Index (NDI) were used to determine 5-year survival.

Based on our findings, neighborhood concentrated disadvantage was negatively associated with survival among nHBlack and nHWhite breast cancer patients. In unadjusted models, social network size, network density, practical support, and financial support were positively associated with 5-year survival. However, in adjusted models only practical support was associated with 5-year survival. Our findings suggest that the association between network size and breast cancer survival is sensitive to scaling of the network measure, which helps to explain inconsistencies in past findings. Social networks of nHWhites and nHBlacks differed in size, social support dimensions, network density, and geographic proximity. Among social factors, residence in disadvantaged neighborhoods and unmet practical support explained some of the racial disparity in survival. Differences in late stage diagnosis and comorbidities between nHWhites and nHBlacks also explained some of the racial disparity in survival.

Our findings highlight the relevance of social factors, both macro and inter-personal in the racial disparity in breast cancer survival. Findings suggest that reduced survival of nHBlack women is in part due to low social network resources and residence in socially and economically deprived neighborhoods. Our findings indicate that, to improve survival among breast cancer patients, policies need to focus on continued improvement of access to care and reduction of racially patterned social and economic hardship. Additionally, our findings support the need for health care providers to assess social support resources of breast cancer patients at the time of diagnosis.

Keywords

breast cancer survival; breast cancer mortality; racial disparities; social networks; neighborhood context; African American

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Authors

Ganga Vijayasiri, Yamile Molina, Ifeanyi B. Chukwudozie, Silvia Tejeda, Heather Pauls, Garth Rauscher, Richard T. Campbell, and Richard B. Warnecke

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School of Community Health Sciences
University of Nevada, Las Vegas

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Ganga Vijayasiri, University of Illinois at Chicago
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Richard T. Campbell, University of Illinois at Chicago
Richard B. Warnecke, University of Illinois at Chicago
Corresponding Author: Ganga Vijayasiri, gvijay2@uic.edu

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INTRODUCTION

Breast cancer survival rates have improved in recent decades, but the improvement in five-year survival at each tumor stage has been lower for non-Hispanic Black (nHBlack) women than for non-Hispanic White (nHWhite) women (Ademuyiwa, Edge, Erwin, Orom et al., 2011; Boyer-Chammard, Taylor, & Anton-Culver, 1999; Chlebowski, Chen, Anderson, Rohan et al., 2005; Dehal, Abbas, & Johna, 2013; Gwyn, Bondy, Cohen, Lund et al., 2004; Li, Malone, & Daling, 2003; Rose & Royak-Schaler, 2001; Shavers & Brown, 2002; Whitman, Orsi, & Hurlbert, 2012). In 2012, the five year survival rate in the United States was 91% for nHWhites, but 80% for nHBlacks (Howlader N, Noone AM, Krapcho M, Garshell J et al.). The disparity has been greater in Chicago; for example, in 2005 the breast cancer mortality rate ratio among nHBlacks vs. nHWhites was 1.9 compared with the national rate ratio of 1.4 (Hunt, Whitman, & Hurlbert, 2014; Whitman, Ansell, Orsi, & Francois, 2011).

Known factors associated with breast cancer mortality include advanced stage at diagnosis (Yu, 2009), non-adherence to mammography screening (Jorgensen, 2010; Myers, Moorman, Gierisch, Havrilesky et al., 2015), comorbidities (Land, Dalton, Jorgensen, & Ewertz, 2012), obesity (Chan, Vieira, Aune, Bandera et al., 2014; Protani, Coory, & Martin, 2010), and smoking (Berube, Lemieux, Moore, Maunsell et al., 2014). There has also been considerable attention on social causes of breast cancer mortality. Studies focusing on macro social factors have mainly examined median income and area-based socio-economic status (Akinyemiju, Genkinger, Farhat, Wilson et al., 2015). However, the associations between the residential environment and breast cancer mortality have been inconsistent, with different studies showing both higher and lower mortality in areas with low composite socio-economic status (Bhuyan, Stimpson, Rajaram, & Lin, 2014; Harper, Lynch, Meersman, Breen et al., 2009; Panczak, Galobardes, Voorpostel, Spoerri et al., 2012; Pollock & Vickers, 1997; Williams, Clifford, Hopper, & Giles, 1991). Studies focusing on the influence of social network factors on breast cancer survival have examined the influence of social integration (Beasley, Newcomb, Trentham-Dietz, Hampton et al., 2010; Kroenke, Kubzansky, Schernhammer, Holmes et al., 2006; Kroenke, Michael, Poole, Kwan et al., 2017; P. Reynolds, Boyd, Blacklow, Jackson et al., 1994), size and composition of social networks (Chou, Stewart, Wild, & Bloom, 2012; Weihs, Simmens, Mizrahi, Enright et al., 2005), and social support (Beasley, Newcomb, Trentham-Dietz, Hampton et al., 2010; Butow, Coates, & Dunn, 2000; Chou, Stewart, Wild, & Bloom, 2012; Kroenke, Kubzansky, Schernhammer, Holmes et al., 2006;

Maunsell, Brisson, & Deschenes, 1995; P. Reynolds, Boyd, Blacklow, Jackson et al., 1994). However, despite considerable inquiry, mostly in the last decade, there is no consensus on the specific associations between social networks and survival. Thus, several studies found that socially integrated breast cancer patients had increased survival (Beasley, Newcomb, Trentham-Dietz, Hampton et al., 2010; Kroenke, Kubzansky, Schernhammer, Holmes et al., 2006; Kroenke, Michael, Poole, Kwan et al., 2017; J. R. Marshall & Funch, 1983) but at least one study found no association between social integration and survival (P. Reynolds, Boyd, Blacklow, Jackson et al., 1994). With regard to network size, a number of studies have found a positive association between number of supportive friends and relatives and survival (Waxler-Morrison, Hislop, Mears, & Kan, 1991; Weihs, Simmens, Mizrahi, Enright et al., 2005), while one study found a negative effect (Cousson-Gelie, Bruchon-Schweitzer, Dilhuydy, & Jutand, 2007) and another found no association (Chou, Stewart, Wild, & Bloom, 2012). Others have found only race-specific effects. Thus, Reynolds (1994) found a positive association between network size and breast cancer-specific survival for whites but not for Blacks, while Kroenke (2017) found such an association only for non-white women. With regard to social support, Maunsell (2006) found that a composite measure of social support was associated with longer survival among breast cancer patients while others (Butow, Coates, & Dunn, 2000; Kroenke, Kubzansky, Schernhammer, Holmes et al., 2006) found no association. The few studies that have looked at the influence of specific support dimensions on breast cancer survival (Chou, Stewart, Wild, & Bloom, 2012; P. Reynolds, Boyd, Blacklow, Jackson et al., 1994) have generally found emotional support to be the primary support dimension to have a protective influence on survival.

The current study aims to address some of the methodological limitations in extant literature. Macro social conditions including residential segregation, socio-economic status (SES), and neighborhood social disorder are potential antecedents to formation of social network ties. However, past investigations on breast cancer survival, overall and specifically in terms of disparities have focused on either macro-level social factors (Bhuyan, Stimpson, Rajaram, & Lin, 2014; Harper, Lynch, Meersman, Breen et al., 2009; Panczak, Galobardes, Voorpostel, Spoerri et al., 2012; Pollock & Vickers, 1997; Pruitt, Lee, Tiro, Xuan et al., 2015; Williams, Clifford, Hopper, & Giles, 1991) or social network factors (Beasley, Newcomb, Trentham-Dietz, Hampton et al., 2010; Butow, Coates, & Dunn, 2000; Chou, Stewart, Wild, & Bloom, 2012; Cousson-Gelie, Bruchon-Schweitzer, Dilhuydy, & Jutand, 2007; Kroenke, Kubzansky, Schernhammer, Holmes et al., 2006; Kroenke, Michael, Tindle, Gage et al., 2012; Maunsell, Brisson, & Deschenes, 1995; P. Reynolds, Boyd, Blacklow, Jackson et al., 1994), but both social domains have not been examined simultaneously. Moreover, for each social domain, there have been challenges in assessing factors associated with survival.

One reason for mixed results in the association between residential environment and breast cancer mortality may be the inability of purely economic measures to adequately gauge neighborhood disadvantage. To overcome this limitation, our study uses area-level disadvantage measures that assess both economic and social deprivation. With regard to studies examining the association between social network and support factors and survival, important network attributes such as the degree to which one's network is close-knit or the geographic proximity of network members have not been included in previous models. In addition, there have been other methodological limitations such as poorly measured psychosocial measures and insufficient simple sizes (Chou, Stewart, Wild, & Bloom, 2012). While most past studies have used the concept

of social integration (Berkman & Syme, 1979) or a count of friends and relatives as a measure of patients' social networks, we use an ego-network measurement tool (Peter V. Marsden, 2005) that allows us to assess the various structural, compositional, and resource elements of breast cancer patients' social networks.

Although characteristics of the social networks of nHBlack and nHWhite breast cancer patients have been shown to differ (Kroenke, Quesenberry, Kwan, Sweeney et al., 2013; P. Reynolds, Boyd, Blacklow, Jackson et al., 1994) the effect of these differences on survival disparities is unknown. While recent social network studies reflect a sustained effort to clarify the association between social networks and breast cancer survival, to our knowledge there are no population-based studies that examine the mediating role of social network structural and resource factors on the racial disparity in breast cancer survival. With the goal of determining how social context at the macro and at the inter-personal level influences breast cancer survival, we first test the mediating role of macro-social context and social network factors in the racial/ethnic survival disparity. Quantifying and comparing specific mediators will help identify potential points for intervention and those that may be most effective for eliminating disparities. Second, we address methodological challenges by distinguishing between structural (e.g. network size, network density, and geographic proximity of the network) and resource (e.g. social support) components of social networks. Also based on the recognition that specific structural metrics affect support dimensions differently (for example, the differential influence of network density on practical support vs. informational support) (Gagliardi, Vespa, Papa, Mariotti et al., 2009; Granovetter, 1973; P. V. Marsden & Friedkin, 1994), we use individual social support dimensions instead of a composite measure. As coordination of patient support probably depends on more than a single, structural or compositional network characteristic (Gagliardi, Vespa, Papa, Mariotti et al., 2009), by simultaneously examining the effects of key social network metrics we are able to avoid the problematic issues resulting from the use of a single network metric. Toward that goal, we use data from a sample of 786 recently diagnosed breast cancer patients to determine how macro and inter-personal social factors influence breast cancer survival and the extent to which these factors mediate the association between race and survival.

The theoretical framework guiding our analyses and model testing is derived from Berkman's research on the effects of social networks on individual behavior (Berkman, Glass, Brissette, & Seeman, 2000) and literature on potential pathways linking informal social networks to breast cancer survival (Beasley, Newcomb, Trentham-Dietz, Hampton et al., 2010; Pinquart & Duberstein, 2010). Our framework (Figure 1) includes neighborhood social environment as a contextual antecedent to the emergence and function of informal social networks. Macro social, cultural, economic, and political conditions function as preconditions and precursors to social network tie formation and determine the form and content of these ties (Lin, 1999). For example, racial segregation and concentration of poverty in urban areas has resulted in socially and spatially isolated communities; the social conditions of high unemployment, derelict housing, family disruption, and high crime in these communities lead to lack of social cohesion, smaller and weaker social networks (Massey & Denton, 1993; Small, 2007; Tigges, Browne, & Green, 1998), and less heterogeneous social ties (DiPrete, Gelman, McCormick, Teitler et al., 2011). Additionally, according to our framework, social support, characterized as a mobilized network resource, is determined, in part, by network structure. The association between race/ethnicity and breast cancer survival is conceptualized as mediated through neighborhood social context and personal networks; the

framework assumes that social factors affect survival through improving availability of health information and access to better and more timely care. For example, network members may prompt at risk women to get screened, leading to early detection. Additionally, network members may help cancer patients navigate complexities of the health care system, provide vital information about providers and care delivery systems (e.g. cancer centers), help patients to attend all scheduled follow-up visits, and encourage patients to maintain a healthful diet (Pinquart & Duberstein, 2010).

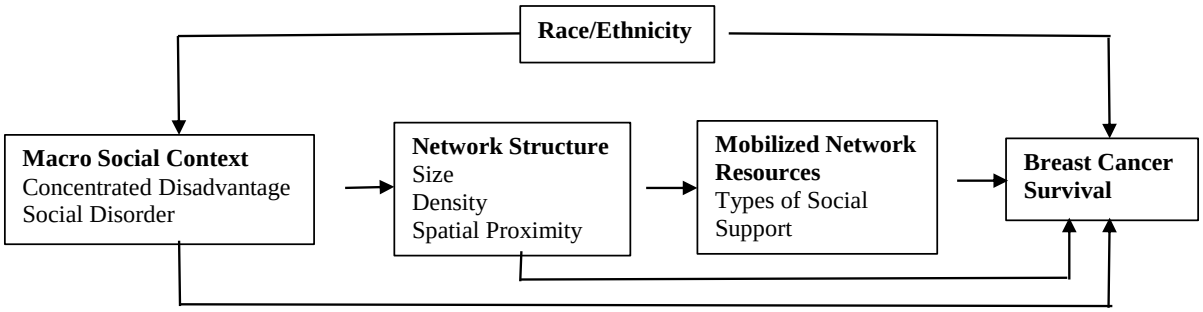

Figure 1. Conceptual Model of Social Network Effects on Breast Cancer Survival

METHODS

Procedures

With the assistance of the Illinois State Cancer Registry, during 2005 to 2008, the (BLINDED) study invited newly diagnosed breast cancer patients who were identified using rapid case ascertainment to participate. The Institutional Review Boards of the (BLINDED) and the State of Illinois Department of Public Health approved the (BLINDED) study. Details of the study methodology have been described previously (Anonymous, 2015). Briefly, data include interviews of 989 recently diagnosed breast cancer patients (response rate=56%). Eligible patients were female, diagnosed between ages 30–79, self-identified as either nHWhite, nHBlack or Hispanic, and a Chicago resident when diagnosed. All patients (416 nHBlack, 398 nHWhite, and 175 Hispanic) provided written consent to a computer-assisted personal interview. In addition, 863 patients provided written consent allowing abstraction of their medical records for diagnostic information. Data on vital status and cause of death were obtained in 2015 from the NDI. Data on vital status for Hispanics were considered unreliable due to outmigration; thus, the current sample is limited to 791 nHBlack and nHWhite respondents for whom NDI data were available.

Breast Cancer Survival

Mortality data from the NDI were used to determine 5-year survival. Person-years of follow-up were counted from the date of diagnosis until the date of death or end of follow-up (December 31, 2014), whichever came first. Follow-up ranged from 0.5 to 8.7 years with a median of 7 years. The outcome in our study was breast-cancer specific mortality and follow-up was limited to five years. Where the death occurred within 5-years of diagnosis the patient was coded 1, otherwise the patient was coded 0.

Macro-social Context Factors

We measured macro-social context of the patient's place of residence using the *Index of Concentrated Disadvantage* (Cagney & Browning, 2004) and *perceived neighborhood social*

disorder. The Index of Concentrated Disadvantage calculated using 2010 census data combines percentages below poverty, unemployed, in female-headed households, under age 18 years, and nHBlack. Following the methodology used in past studies on the association between area-based disadvantage and breast cancer mortality (Dasgupta, Baade, Aitken, & Turrell, 2012; Panczak, Galobardes, Voorpostel, Spoerri et al., 2012; Pollock & Vickers, 1997; Schrijvers, Mackenbach, Lutz, Quinn et al., 1995), we categorized concentrated disadvantage values into quintiles with higher quantiles representing greater disadvantage. Perceived neighborhood social disorder was generated by taking the summed average across six items (broken glass or trash on streets, graffiti on walls and buildings, number of vacant houses, public drinking, selling and using drugs in public, and unsupervised children on streets) based on the Project on Human Development in Chicago Neighborhoods (Earls, 1999). The responses for the six items were collected on a 4-point Likert scale from 1 = a great deal to 4 = not at all.

Social Network Factors

Patients' personal network data were collected using an ego-network measurement tool consisting of a network name generator, a network name interpreter, a network relationship examiner, a network name inter-relater, and a spouse relationship examiner (Peter V. Marsden, 2005). The name generator asked "People look to others for various sorts of help such as companionship, prayer, information, baby-sitting, and money when they have serious health problems. Since you were diagnosed with breast cancer, who are the people who have provided you with the most important help? Please exclude your spouse/partner and health care providers." Patients were asked to nominate as many as five of their most helpful friends or relatives, excluding their spouse/partner. The name interpreter collected demographic information, residential location, and type of social support supplied by each network member. The name inter-relater asked about the relationships among all possible pairs of network members within each patient's personal network. All nominations of network members were collected prior to asking detailed information on any specific network member to maximize the number of social network connections that were reported.

Network factors were calculated for each individual. *Network size* is the number of friends and relatives who offered help since diagnosis and could range from 0 to 5. The *Network density* of a patient's ego network was measured by summing existing ties between network members and dividing by the maximum number of possible ties. We also measured *geographic proximity* of the network with the average distance between place of residence of network members and patient. Driving distance between the patient's residence and residences of their network members were calculated using the OD Cost Matrix Network Analyst tool in ArcGIS Version 10.1 (ESRI, 2014). We also measured whether the patient had a *spouse or partner.* Five types of *social support* received by patients since diagnosis were also measured:(1) emotional help or support (2) spiritual help or support (3) financial help or support (4) assistance with practical or everyday matters and (5) help with information, such as suggestions for doctors or advice on what the respondent should do about her health. For each of the five dimensions of support the study used "unmet need" as a predictor. For each of the five support dimensions, unmet need was measured with two indicators: amount of support needed and the amount of actual support received. For example, for practical support, the survey asked "Since you were diagnosed with breast cancer how much assistance with practical or everyday matters have you needed?" and "Since you were diagnosed with breast cancer, how much practical help or support have you received, from anyone?". Each question was

assessed with four response options: None, A Little, Some, and A Great Deal. For each of the five support dimensions, unmet need was assessed as the difference between support needed and actual support received. This measure ranged from -3 to 3, with higher values indicating greater unmet need.

Demographic and Health Factors

Demographic factors included self-reported age, socio-economic status, and health insurance status. Socio-economic status was calculated as the sum of standardized household income (range: $0 - 225,000) and standardized years of education completed (range: 0 -18). *Stage at diagnosis* of breast cancer was based on the surgical pathology report abstracted from the patient's medical record and was coded using the American Joint Commission on Cancer staging system (Edge & Compton, 2010). Stages 2, 3, and 4 were coded as late stage. *Adjuvant therapy* based on both medical record abstraction and self-reports assesses whether radiation, chemotherapy, and hormone therapy treatments were initiated. For each treatment type, a binary variable was coded as '1' for those who had begun the treatment. *Comorbidities* were determined from patient responses to the question: "Did you have any health problems or existing conditions at the time you were diagnosed with breast cancer that required seeing a doctor or health care practitioner on a regular basis such as asthma, high blood pressure, diabetes, heart disease, or something else?" The number of health problems reported were summed to create this variable.

Statistical Analysis

Descriptive statistics for the predictors and the outcome in our analytic models are shown in Table 1. Statistically significant differences between nHWhite and nHBlack patients were calculated for each predictor and the outcome. We also assessed the crude, unadjusted relationship between each of the predictors and death from breast cancer within 5 years of diagnosis (Table 2). Descriptive analyses were conducted using Stata13 (StataCorp, 2013) and all multivariate analyses were done using Mplus7 (Muthén & Muthén). Analyses were weighted to bring the sample back to its correct proportional representation. Guided by our conceptual model of social network effects on breast cancer survival (Figure 1), we tested a series of regression models.

We initially tested a logistic regression model that had race as the single predictor. Then five additional models were tested, where macro-social factors, social network factors, individual demographic and health/clinical factors were successively added. Finally, we used structural equation modeling (SEM) as implemented in Mplus7 to test mediation paths suggested by the sequence of regression models. The SEM model only included statistically significant predictors as indicated in the final regression model.

Of the 791 respondents for whom data on the outcome, 5-year survival, were available, data on cancer stage were missing for 12.97%, and network density and mean distance to network members was missing for 7.48% and 3.24% respectively. Three other variables, namely marital status, initiation of adjuvant therapy, and unmet spiritual support, were missing for less than 2% of the sample. In multivariate analyses the full information maximum likelihood (FIML) (Enders & Bandalos, 2001) method was used to address missing data on cancer stage, network density, and distance to alters. This method allows each case to contribute to the analysis proportional to the information available.

RESULTS

Descriptive Results

Of the final analytic sample of 786 breast cancer patients, 50.6% were nHBlack and 49.4% were nHWhite. With regard to 5-year breast cancer mortality, nHBlacks had an eight-percentage point higher probability of death within five years of diagnosis compared to nHWhites (Table 1). Among patients who died within five years of diagnosis, the average time of survival was slightly lower among nHBlacks compared to nHWhites (2.8 years vs. 2.9 years). With regard to macro-social context factors, nHBlacks were more likely to live in neighborhoods with high concentrated disadvantage while nHWhites were more likely to live in low concentrated disadvantage neighborhoods; specifically, only 2% of nHBlacks were in the 1st quintile (quintile representing least disadvantage) while 38% were in the 5th quintile (quintile representing most disadvantage); an opposite trend was observed for nHWhites, with 40% in the 1st quintile and only 1% were in the 5th quintile. With regard to social network factors, nHBlacks reported slightly fewer help-giving friends or relatives and were less likely to report being married, but tended to report more dense and more geographically concentrated networks compared to the networks of nHWhites. Nonetheless, nHBlacks reported more unmet practical and financial need than nHWhites. With regard to demographics and health, nHBlacks had lower individual socioeconomic status, lower odds of private health insurance, greater odds of late stage detection, and more co-morbidities.

Table 1: Five-Year Mortality, Macro-Social Factors, Social Network Factors and Demographic and Clinical Factors by Race/Ethnicity (N=786)[a]

	Range	NHWhite (N=388)	NHBlack (N=398)	P value[b]
Outcome				
5-Year Mortality (%)		4	12	<0.001
Mean time to breast cancer death (Years)	0.51- 4.86	2.91 (1.36)	2.77 (1.33)	0.09
Macro-Social Factors				
Concentrated Disadvantage Quintiles (%)	-3.86 - 17.72			<0.001
1st		40	2	
2nd		33	6	
3rd		21	20	
4th		6	33	
5th (greatest disadvantage)		1	38	
Mean Neighborhood Social Disorder	1-4	1.77 (0.54)	2.2 4 (0.71)	<0.001
Social Network Factors				
Number of Network Members	0 - 5	4.18 (1.30)	3.93 (1.46)	0.05
0		2.6	4.02	
1		3.9	4.8	
2		5.9	9.3	
3		10.8	12.8	
4		14.2	13.8	
5		62.6	55.3	
Mean Network Density	0 - 10	3.73 (3.14)	6.58 (3.40)	<0.001
Mean Spatial Proximity of Network (miles)	0 - 757	171.22 (235.57)	85.89 (161.34)	<0.001
Married (%)		49	30	<0.001
Mean Unmet Support Measures				
Emotional	-3 - 3	-0.72 ((0.91)	-0.68 (1.14)	0.74
Spiritual	-3 - 3	-0.22 (0.95)	-0.21 (0.95)	0.92
Practical	-3 - 3	-0.56 (0.96)	-0.31 (1.13)	0.001
Financial	-3 - 3	0.02 (1.07)	0.50 (1.38)	<0.001
Informational	-3 - 3	-0.55 (1.03)	-0.43 (1.20)	0.13
Individual Factors				
Demographic				
Mean Age (years)	28 - 79	55.96 (11.19)	56.93 (11.29)	0.19
Mean SES Score	-2.67 - 2.20	0.51 (0.78)	-0.2 (0.58)	<0.001
Health/Clinical				
% with Private Health Insurance		90	58	<0.001
Mean Number of Comorbidities	0 - 6	0.52 (0.90)	0.91 (1.10)	<0.001
% with Late Stage Cancer		36	48	0.002
% with Adjuvant Therapy		88	86	0.19
% Radiation Therapy Initiated		62	53	0.01
% Chemotherapy Initiated		36	51	<0.001
% Hormone Therapy Initiated		49	37	<0.001

[a] For all continuous variables, standard deviations are provided in parenthesis next to the mean.

[b] P-values test for NHWhite vs. NHBlack differences. For binary variables P-values are based on logistic regression and for continuous variables P-values are based on OLS regression. P- values for concentrated disadvantage quintiles are based on ordinal logit models and P-values for network members and number of comorbidities are based on Poisson regression.

Table 2 presents bivariate associations between predictors in our model and 5-year breast cancer mortality. Just as in Table 1, Table 2 shows that nHBlacks have a statistically higher probability of breast cancer mortality than nHWhites. Out of the macro-social context factors, concentrated disadvantage was positively related to mortality. With regard to social network size, patients reporting a network size of either 3, 4, or 5 had the same (7%) likelihood of 5-year mortality; regarding network size, the only statistically significant difference was that compared with a 5-member network, a 2-member network was associated with higher risk of mortality. Network density, unmet practical need, and unmet financial need were associated with a higher likelihood of mortality. Regarding health factors, late stage diagnosis, number of comorbidities, and treatment type were associated with mortality.

Table 2: Unadjusted Associations between breast cancer mortality within 5 years of diagnosis and Predictors (N=786)

	N	Five-year Mortality[a]	P value[b]
Race/Ethnicity			<0.001
NHWhite	388	4	
NHBlack	398	12	
Macro-Social Factors			
Concentrated Disadvantage Quintiles			
1st	160	2	ref
2nd	154	3	0.52
3rd	161	11	<0.01
4th	155	12	<0.01
5th (greatest disadvantage)	156	11	<0.01
Neighborhood Social Disorder		1.16	0.43
Social Network Measures			
Number of Network Members			
0	26	11	0.64
1	34	3	0.38
2	60	18	<0.01
3	93	7	0.86
4	110	7	0.97
5	463	7	ref
Network Density		1.1	0.02
Spatial Proximity of Network (miles)		0.99	0.25

[a] Percentage of prevalence of 5-year breast cancer mortality is reported for categorical predictors while odds ratio of 5-year breast cancer mortality is reported for continuous predictors.

[b] P-values are based on logistic regression.

Table 2: Unadjusted Associations between breast cancer mortality within 5 years of diagnosis and Predictors (N=786) - CONTINUED

	N	Five-year Mortality[a]	P value[b]
Married			0.83
Yes	308	8	
No	478	8	
Mean Unmet Support Measures			
Emotional		1.23	0.16
Spiritual		1.08	0.6
Practical		1.65	<0.001
Financial		1.28	0.04
Informational		0.98	0.85
Individual Factors			
Demographic			
Age (years)		0.72	0.09
SES Score		0.98	0.06
Health/Clinical			
Private Health Insurance			0.63
Yes	584	7	
No	202	9	
Late Stage Cancer			<0.001
Yes	289	17	
No	396	1	
Radiation Therapy			0.23
Yes	447	7	
No	334	9	
Chemo Therapy			<0.001
Yes	342	15	
No	440	2	
Hormone Therapy			0.02
Yes	334	5	
No	443	10	
Adjuvant Therapy			0.64
Yes	683	8	
No	103	6	
Number of Comorbidities			0.05
0	446	9	
1	188	10	
2	97	5	
3	55	2	

[a] Percentage of prevalence of 5-year breast cancer mortality is reported for categorical predictors while odds ratio of 5-year breast cancer mortality is reported for continuous predictors.

[b] P-values are based on logistic regression.

Multivariate Results

Table 3 presents a sequence of regression models that successively add macro-social contextual, social network, and demographic and health factors to a race/ethnicity only model. In the unadjusted logistic regression model 1, nHBlacks had much higher odds of mortality than nHWhites (OR=3.43; p <.001). After adjusting for neighborhood context, social network factors, and patient-level demographic and clinical factors, the association between race and mortality was reduced in magnitude and was no longer significant (OR=2.01; p = 0.13). In the fully adjusted model, concentrated disadvantage, unmet practical support, and late stage cancer were positively related to mortality while number of comorbidities were negatively related to mortality. In the unadjusted results in Table 2, there was some indication that larger networks were associated with reduced mortality. However, in Table 3, network size treated as a continuous variable was not associated with mortality. Studies that found an association between social network size and mortality used a categorical network size variable (Kroenke, 2017; Reynolds, 1994; Waxler-Morrions 1991; Weihs, 2005). To determine whether findings are sensitive to the linearity assumption, we re-ran our regression models dichotomizing network size -- 0-2 members versus three and above. In these models, while other coefficients remained unchanged, network size showed a marginally significant, positive association with survival (results not shown).

We used findings from our fully adjusted regression model to guide the building of a mediation model to test our hypotheses. We specifically tested mediation through disadvantage, unmet practical need, stage at diagnosis, and comorbidities. Figure 2 presents results from the structural equation model. Racial differences in 5-year mortality were mediated by residence in high disadvantage neighborhoods, unmet practical need, receipt of a late stage diagnosis, and number of comorbidities. Based on Figure 2, most of the association between race/ethnicity and mortality observed in the unadjusted model is by intervening variables as specified in the SEM model.

Table3: Logistic Regression Models Predicting Five-Year Mortality (N=786)[a]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Race/Ethnicity						
NHBlack	3.43***	1.96~	1.92~	1.87	1.80	2.01
Macro-Social Factors						
Concentrated Disadvantage						
1st Quintile		ref	ref	ref	ref	ref
2nd		1.49	1.51	1.48	0.52	1.81
3rd		1.38*	4.02*	3.8*	3.61*	3.55*
4th		1.42*	4.04*	3.83*	3.44~	4.04*
5th (greatest disadvantage)		1.36~	3.91~	3.74~	3.23~	3.31~
Neighborhood Social Disorder		0.78	0.79	0.79	0.77	0.80
Social Network Factors						
Number of Network Members			0.91	0.91	0.97	0.97
Network Density				1.04	1.05	1.04
Proximity of Network (miles)				1.00	1.00	1.00
Married				1.28	1.36	1.49
Unmet Support Measures						
Emotional					1.15	1.06
Spiritual					0.96	0.92
Practical					1.51**	1.58**
Financial					1.07	1.13
Informational					0.83	0.85
Individual Factors						
Demographic						
Age (years)						1.00
SES score[e]						0.89
Health/Clinical						
Private Health Insurance						1.84
Number of Comorbidities						0.71*
Late Stage Cancer						10.06***
Treatment Type						
Radiation Therapy						0.76
Chemo Therapy						1.66
Hormone Replacement Therapy						0.74

[a]Reported coefficients are odds ratios; ~p<.1 *p<.05; **p<.01; ***p<.001

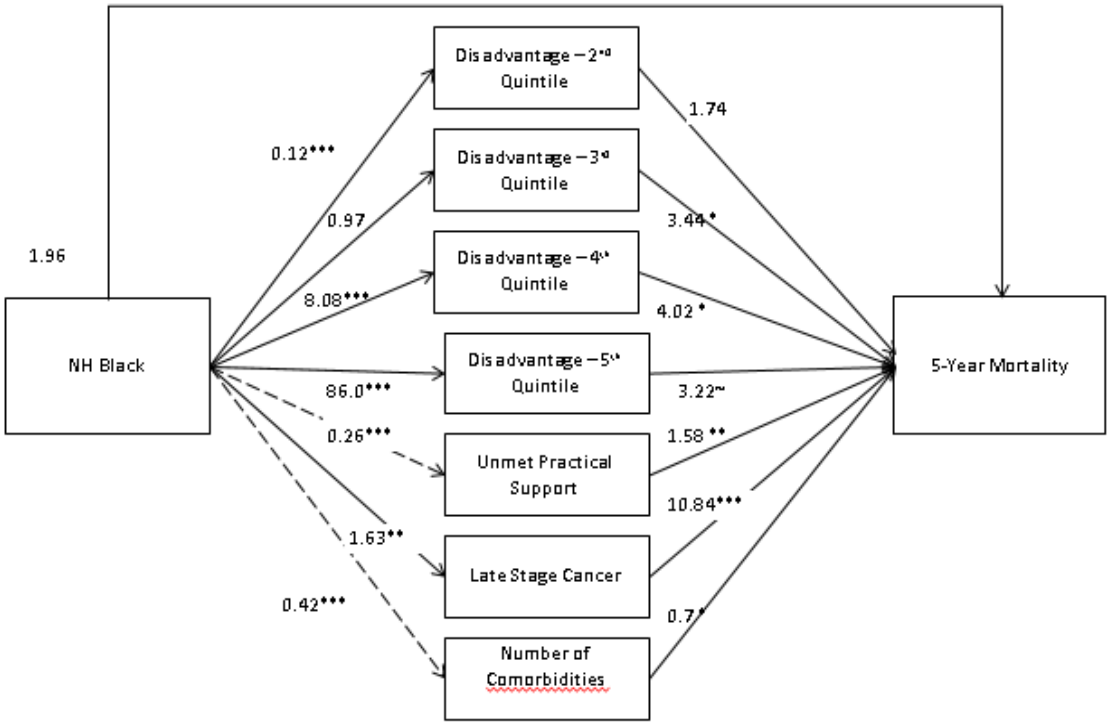

Figure 2. Path Diagram Showing Indirect Associations between Race and Breast Cancer Mortality from the SEM model. The model adjusts for the other variables in the final regression model, Model 5 in Table 3. In the diagram, odds ratios are reported for binary outcomes and are indicated by a solid line while slope coefficients are reported for continuous outcomes and are indicated by a broken line.
~p<.1; *p<.05; **p<.01; ***p<.001

DISCUSSION

Understanding the reasons for the racial disparity in breast cancer survival is a continuing public health concern, and a priority as indicated by both the American Society of Clinical Oncology and American Cancer Society (American Cancer Society; Moy, Polite, Halpern, Stranne et al., 2011). Toward that goal, the current study addressed several gaps in extant observational research. Specifically we addressed previous studies' limitations pertaining to social determinants of health, including the use of area-based measures that capture composite-SES (Bhuyan, Stimpson, Rajaram, & Lin, 2014; Du, Fang, & Meyer, 2008; Harper, Lynch, Meersman, Breen et al., 2009; Keegan, Kurian, Gali, Tao et al., 2015) but not other indicators of area disadvantage such as residential racial segregation, the proportion of single-parent households, and social disorder. We also used an ego-network measurement tool to assess adequately various structural and functional aspects of breast cancer patients' personal networks. Finally, our study is among the first to simultaneously examine the mediating effects of macro-social context and network factors on racial disparities in breast cancer mortality.

As noted above, past studies examining the relationships between macro-social context factors and breast cancer mortality have been conflicting: some studies have found an inverse relationship between area-level SES and mortality and others not. Our findings suggest that residence in disadvantaged neighborhoods is related to higher breast cancer mortality and contributes to the racial disparity in breast cancer mortality. Unlike area-based SES used in some prior studies, the Index of Concentrated Disadvantage used in this study may capture additional aspects of social disadvantage that impact health literacy and access. Thus, one potential explanation for this observed relationship concerns the lack of or limited screening and diagnostic services in disadvantaged neighborhoods (Coughlin, Leadbetter, Richards, & Sabatino, 2008; Elkin, Ishill, Snow, Panageas et al., 2010). Another potential mechanism linking residential context to breast cancer survival could be lifestyle factors such as diet and physical activity that tend to correlate with SES and race (Keegan, Kurian, Gali, Tao et al., 2015) and stress and anxiety due to residential crime and safety concerns (Feldman & Steptoe, 2004; Steptoe & Feldman, 2001).

While macro social conditions such as residential segregation and concentrated poverty may be negatively correlated with social cohesion and social network tie formation in these communities, there also are examples where marginalized communities have used informal social networks as adaptive tools to confront macro-social challenges. This is clear in the innovative use of social network ties by members in ethnic-enclaves to find employment and to achieve entrepreneurial goals (Ndofor & Priem, 2011; Portes & Sensenbrenner, 1993), by low-income, minority mothers to survive and to gain social mobility (Domínguez & Watkins, 2003), and by farm communities in the rural south to overcome ecological challenges (Rockenbauch & Sakdapolrak, 2017). Our findings show that residence in disadvantaged neighborhoods is a risk factor for higher breast cancer mortality among nHBlack. Increasing social cohesion and social mobilization of these communities may bring about network advantages similar to the ones witnessed in other marginalized communities, that may result in attracting needed social and health services. As an example, area designation as Medically Underserved Areas (which is a precursor to establishment of federally qualified health centers in a locality) is in part determined by community activism and mobilization for such designation. Recent findings also suggest that residence in undesignated areas to be one of the strongest predictors of later stage at diagnosis for nHBlack women (R.B. Warnecke, Campbell, Vijayasiri, Barrett et al., Pending). Thus, mobilizing network resources in segregated, urban African American neighborhoods may bring health benefits that could help reduce racial disparities in breast cancer outcomes.

With regard to social support, only practical support was related to longer survival and the disparity in mortality. Our results indicate that the lower practical support available to nHBlacks relative to nHWhites is associated with the higher mortality observed for nHBlacks. A possible reason for the higher unmet practical support reported by nHBlacks could be the greater care-giving burdens and relationship strain experienced by nHBlacks compared to nHWhites (Kroenke, Michael, Tindle, Gage et al., 2012). Greater social burdens and unmet social support needs of breast cancer patients could lead to poorer quality of life (Friedman, Kalidas, Elledge, Chang et al., 2006; Ozkan & Ogce, 2008; J. S. Reynolds & Perrin, 2004; Sammarco & Konecny, 2008) that in turn is shown to influence breast cancer survival (De Aguiar, Bergmann, & Mattos, 2014; Epplein, Zheng, Zheng, Chen et al., 2011; Svensson, Hatschek, Johansson, Einbeigi et al., 2012).

In adjusted models, network size was unrelated to mortality. However, there was little variability at the low end of this measure and that may have contributed to this observed finding.

Results in adjusted models that used a dichotomized network size variable, however, suggested that larger networks were associated with decreased mortality. It is possible that there are qualitative differences between small and large networks; for example, compared to a one or two member network, the structure of larger networks may facilitate greater social control and accountability. Given the evidence that findings are likely sensitive to the scaling of the social network measure, future research should further explore the association between network size and mortality to clarify this association. In our sample, social networks of nHBlacks were geographically concentrated and close-knit compared to networks of nHWhites. Although high density networks could facilitate the flow of support resources (Berkman, Glass, Brissette, & Seeman, 2000) and promote psychological wellbeing (Gagliardi, Vespa, Papa, Mariotti et al., 2009), in our study network density or geographic proximity of the network were not associated with survival.

In our sample, about seven percent of the respondents reported having no support-providing network members or having just one. Our finding that social ties and social support help improve survival among breast cancer patients supports the assessment of patients' social networks and social support needs at the time of cancer diagnosis and the matching of support-volunteers from community-based organizations with socially isolated patients.

With regard to health variables, our finding that stage at diagnosis was related with increased mortality is consistent with earlier studies (Du, Fang, & Meyer, 2008; Klemi, Parvinen, Pylkkanen, Kauhava et al., 2003; Sener, Winchester, Winchester, Barrera et al., 2006). That stage at diagnosis constitutes a strong predictor is not surprising given it represents a proximal factor to survival (Blackman & Masi, 2006). Though most studies have found a negative association between comorbidities and survival (Du, Fang, & Meyer, 2008; Hershman, McBride, Jacobson, Lamerato et al., 2005; Land, Dalton, Jorgensen, & Ewertz, 2012), in our study, similar to findings by Keegan et al. (Keegan, Kurian, Gali, Tao et al., 2015), comorbidities were associated with increased survival.

While our study is among the first to quantify the mediating effects of social determinants at different dimensions, there are several multilevel theoretical frameworks that should guide future efforts (Berkman, Glass, Brissette, & Seeman, 2000; R. B. Warnecke, Oh, Breen, Gehlert et al., 2008). For example, macro-social contextual factors may precede the emergence and function of informal social network factors associated with racial disparities in mortality (Berkman, Glass, Brissette, & Seeman, 2000). It has been suggested that informal social networks function as lay referral systems, promoting appropriate and more effective use of health care services (Bloom & Spiegel, 1984) and, consistent with that, our study indicates that social support resources associated with networks of breast cancer patients are related to increased survival. Future social network research can build on this knowledge and test whether well integrated breast cancer patients are more likely to receive more comprehensive and high standard care, for example care at Breast Imaging Centers of Excellence, than socially isolated women and how that may impact survival. Our findings suggest that intimate social networks of breast cancer patients may make a parallel contribution to that of institutionally funded patient navigation programs that are proven to improve patient outcomes including guideline-concordant screening and timely diagnosis (Battaglia, Darnell, Ko, Snyder et al., 2016; Ko, Darnell, Calhoun, Freund et al., 2014; J. K. Marshall, Mbah, Ford, Phelan-Emrick et al., 2016). However, additional research is needed to fully understand the functioning of breast cancer patients' social networks. Given the protective

effect of social support resources on survival and the findings in previous literature of gradual constriction of the social network and reduction in social exchange and support post- breast cancer diagnosis (Arora, Finney Rutten, Gustafson, Moser et al., 2007; Bloom & Spiegel, 1984; Bloom, Stewart, Chang, & Banks, 2004; Drageset, Lindstrom, Giske, & Underlid, 2012), future research needs to explore how social ties and social exchange can be maintained longer term following a breast cancer diagnosis.

There are several limitations in the current study that future research could address. While 181 Hispanic patients also participated in the (BLINDED) study, we excluded these patients in our current examination. Mortality data for Hispanic patients are considered incomplete due to out-migration, as many Hispanic women return to Mexico or Central America following a breast cancer diagnosis (Lariscy, Hummer, & Hayward, 2015; Markides & Eschbach, 2011). Another limitation of the study was the lack of variability at the low end of the network size measure. While it is encouraging that most patients in our sample reported at least some social support resources at the time of the diagnosis, a significant research concern is to understand the survival outcomes of isolated patients. Given that there was little variability at the lower end of the network size measure in our sample, current findings need to be replicated with a larger sample to clearly understand the impact of social isolation on breast cancer survival. Our study assessed patient social networks and social support in the period immediately following a breast cancer diagnosis, but future research should assess changes in social network dynamics including network stability and fatigue over time and how that influences survival.

Based on our findings, reasons for the racial disparity in survival are the greater propensity of nHBlack women to reside in disadvantaged neighborhoods, to have greater unmet practical support, and to be diagnosed at a later stage. It is clear that public health initiatives for increasing social resources for breast cancer patients should strengthen supportive ties to existing network members, reduce negative interactions in order to reduce the social burden of close ties (Kroenke, Quesenberry, Kwan, Sweeney et al., 2013; Pinquart & Duberstein, 2010), and utilize formal mechanisms to supplement the support needs of breast cancer patients living in disadvantaged communities.

CONCLUSION

Our study attempted to clarify the relationship between macro-social and social network factors and continuing racial disparities in breast cancer survival. While known clinical factors accounted for some of the racial disparity in survival, key social factors that accounted for this disparity were residence in disadvantaged neighborhoods and lack of social support resources. Our findings stress the importance of policy interventions that can address health access barriers and area-based social and economic disadvantage. Our findings also indicate the need for providers to assess patients' social support resources at the time of cancer diagnosis to address their social support needs.

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