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Neighborhood matters: the impact of Hispanic ethnic density on future depressive symptoms 1-year following an ACS event among Hispanic patients

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Abstract The Ethnic Density hypothesis posits that living around others from similar ethnic backgrounds reduces the risk of adverse mental health outcomes such as depression. Contrary to this hypothesis, previous work has shown that Hispanic ethnic density is cross-sectionally associated with *increased* depressive symptom severity among patients hospitalized with an acute coronary syndrome (ACS; myocardial infarction or unstable angina pectoris). To date, no study has examined the prospective association of Hispanic ethnic density on long-term depressive symptom severity following an acute medical event. We prospectively assessed the impact of Hispanic ethnic density on depressive symptoms, 1-year following an ACS event, among Hispanic adult patients. We tested the non-linear association between ethnic density and depressive symptoms to account for inconsistent findings on the ethnic density hypothesis. At the time of an index ACS event (i.e., baseline, N = 326) and 1-year later (N = 252), Hispanic patients from the Prescription Usage, Lifestyle, and Stress Evaluation prospective cohort study completed the Beck Depression Inventory as a measure of depressive symptom severity. Hispanic ethnic density was defined by the percentage of Hispanic residents within each patient's census tract using data extracted from the American Community Survey Census (2010–2013). Covariates included baseline demographic factors (age, gender, English fluency, education, nativity status), cardiovascular factors (Charlson comorbidity index, left ventricular ejection fraction, Global Registry of Acute Coronary Events 6-month prognostic risk score), and neighborhood factors (residential density, income, and percentage of households receiving public assistance). In an adjusted multivariable linear regression analysis there was a significant curvilinear association between Hispanic ethnic density and depressive symptom severity at 1 year. As Hispanic ethnic density increased from low to moderate density, there was an increase in depressive symptoms, but depressive symptoms slightly declined in census tracts with the highest density of Hispanics. Furthermore, gender significantly moderated the relation between Hispanic ethnic density and 1-year depressive symptom severity, such that Hispanic ethnic density was significantly associated with increased depressive symptom severity for female Hispanic patients with ACS, but not for male Hispanic patients. Previous research suggests that ethnic density may be protective against depression in Hispanic enclaves; however, our findings suggest a non-linear ethnic density effect and an overall more complex association between ethnic density and depression. These data add to a growing body of literature on the effects of sociodemographic and contextual factors on health.

Keywords Depression · Ethnic density · Acute coronary syndrome · Neighborhood · Enclave · Heart attack

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Introduction

Depression among individuals with acute coronary syndrome (ACS; myocardial infarction or unstable angina) is prevalent and confers increased risk of cardiovascular-related morbidity and mortality. Approximately 20 % of all patients hospitalized for ACS meet diagnostic criteria for major depressive disorder, and the rates of depression among Hispanics with ACS are as high as 26 % (Thombs et al., 2006; Lichtman, 2014; Urizar, 2006). Research to better understand the predictors of depression risk in the context of ACS has mostly focused on individual-level factors such as demographic (e.g., gender, partner status, education), biological (e.g., inflammation, platelet reactivity, endothelial dysfunction), and clinical (e.g., smoking status, diabetes, comorbid conditions) risk factors, and has thus not fully considered neighborhood-level factors. Previous research on depression in non-ACS populations, however, suggests that neighborhood-level characteristics such as residential density and neighborhood social capital are associated with depression risk (Regoeczi, 2008; Bécares & Nazroo, 2013; Mckenzie, 2008).

One neighborhood-level factor that has garnered recent attention despite its appearance in the sociological literature in the 1930s is ethnic density, or the concentration of individuals of a specific ethnicity within a defined geographic area (Faris & Dunham, 1939; Bécares & Nazroo, 2013; Diez Roux & Mair, 2010). Ethnic density is hypothesized to increase exposure and access to social network resources that in turn may buffer stress and subsequently improve well-being through multiple and complex pathways, including increased access to emotional and tangible social support, attenuated exposure to racial or ethnic discrimination, and strengthened group and self-identity, among other pathways (Shaw et al., 2012).

Although prior research has found support for a protective association of ethnic density on health (Das-Munshi et al., 2010; Gerst et al., 2011; Halpern & Nazroo, 2000; Mair et al., 2010; Stafford et al., 2011; Walters et al., 2008), not all studies have found an inverse association between ethnic density and depression (Pickett et al., 2009; Abada et al., 2007). In fact, tests of the ethnic density effect on depression among Hispanics have been inconsistent (Aneshensel et al., 2007; Wight et al., 2009; Shaw et al., 2012). For example, Mair et al. (2010) found that Hispanic ethnic density was protective against depressive symptoms, only after controlling for neighborhood risk factors such as neighborhood problems (e.g., perceived exposure to crime, violence, drug use and graffiti), neighborhood aesthetics (e.g. ratings of pleasant and attractive neighborhood features), neighborhood safety, and socioeconomic status. More recent studies have observed this trend among generally healthy, community-based samples of Hispanics (mostly Mexican-Americans)—finding that increased neighborhood Hispanic composition was associated with fewer depressive symptoms (Kwag et al., 2012, Shell et al., 2013). However, in a systematic review of ethnic density articles prior to 2011, Shaw and colleagues found that only two out of five studies found a protective ethnic density effect on depression/anxiety among Hispanics. In our own previous cross-sectional study of 472 ACS patients, Hispanic ethnic density was associated with increased depressive symptom severity for both Hispanic and non-Hispanic patients (Denton et al., 2014).

Inconsistent findings in the ethnic density literature may be attributed to the heterogeneity among Hispanic ethnic groups, given the research that has documented variability in health risk by Hispanic ethnic subgroups (CDC, 2015). This variability in health risk has also been found with depression (e.g., Alegría et al., 2007). In the epidemiologic study of the prevalence and development of disease among Hispanics, the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), depressive symptoms were highest among Hispanics of Puerto Rican background, followed by Cubans and Dominicans, and lowest among Hispanics of Mexican background (Hispanic Community Health Study/Study of Latinos, 2013). The HCHS/SOL data also report variation by Hispanic ethnic subgroups on cardiovascular risk factors. Specifically, having a history of hypertension was lowest among those of Mexican and South American backgrounds and highest among those of Cuban, Dominican, and Puerto Rican backgrounds (Hispanic Community Health Study/Study of Latinos, 2013; Daviglus et al., 2012).

Inconsistent findings concerning the protective effect of ethnic density on health may also reflect methodological limitations that fail to capture the complex and possibly non-linear association of ethnic density on depressive symptoms. Further, categorical measures of ethnic density may be oversimplistic and prevent the identification of ethnic density threshold effects (White et al., 2012). For example, in a study of ethnic density and depression among Indian and Pakistani mothers living in 'same ethnic group' areas in the UK, Pickett and colleagues identified different ranges for observed ethnic density effects (Pickett et al., 2009). Specifically, among Indian mothers, they found a protective ethnic density effect on depression at 5–30 % Indian ethnic density, while for Pakistani mothers, a protective effect was only found at 30–50 % Pakistani ethnic density. Instead of targeting ethnic density threshold effects, which may vary by ethnic-subgroup (or measurement of ethnic density), specification of curvilinear functions may better describe the effect of ethnic density on health. Importantly, the utility of social networks and

perceptions of self-identity and social cohesion (or lack thereof) may change across levels of same-group ethnic concentrations (Whitley et al., 2006), thereby necessitating the need to move beyond simple linear models of the association between ethnic density and health outcomes. One study tested both a linear and curvilinear model of ethnic density to study the impact of ethnic density on self-harming behaviors among ethnic minorities in the United Kingdom and found that the curvilinear ethnic density effect produced a better model fit for the data relative to a linear model (Neeleman et al., 2001). Specifically, ethnic density was protective against self-harming behaviors at low and high concentrations of ethnic density, while increased risk of self-harming behaviors was observed at moderate concentrations of ethnic density.

Contextual factors

Ethnic density effects do not operate in a vacuum. In fact, Hispanic ethnic density may contribute to observed patterns of neighborhood health advantage and disadvantage, and toward explanations of the Hispanic Health paradox. Hispanics are paradoxically observed to have decreased mortality rates from heart disease, despite increased cardiovascular risk factors, such as depression, obesity, and low socioeconomic resources (Ruiz et al., 2013). A closer examination of the effect of Hispanic ethnic density on cardiovascular risk factors and depression can provide some understanding of the complex, inconsistent, and sometimes paradoxical findings on Hispanic health outcomes.

Recent findings on context and health draw attention to the impact of neighborhood social context on Hispanic health. For example, Hispanics who reside in New York City were found to have a 2–3 times greater prevalence of depressive symptoms as compared to Hispanics who reside elsewhere in the U.S. (Albrecht & McVeigh, 2012; McVeigh et al., 2006). Moreover, research has found that Dominicans who reside in New York City have higher rates of marital disruption, and worse self-reported health relative to other Hispanic ethnic groups living in New York City (Albrecht & McVeigh, 2012). Such increased social exposures among Dominicans who reside in New York City may contribute to the reported 1.99 greater odds of depressive symptoms when compared to non-Hispanic Whites who also reside in New York City (Albrecht & McVeigh, 2012). Interestingly, Albrecht et al. found that these findings reversed after considering contextual factors: nativity status and English language use. Although not reaching statistical significance, when controlling for nativity status and English language use, New York City Dominicans demonstrated lower depressive symptoms relative to Non-Hispanic Whites living in New York City (Albrecht & McVeigh, 2012). This finding highlights the important and complex interrelation among contextual factors that modify the relationship between ethnic density and Hispanic health.

Contextual modifiers: gender and nativity status

Gender is an important contextual factor to consider in this research, given that women are twice as likely as men to be depressed in the general population (Kessler, 2003). The main effect of gender on depression has also been observed in patients with cardiovascular disease (CVD; Naqvi et al., 2005) and among Hispanics (Maserejian et al., 2012). A few studies have examined gender as a moderator of Hispanic ethnic density and depression (Lee, 2009; Mair et al., 2010; Gerst et al., 2011). These studies have found that men differentially benefit from Hispanic ethnic density when compared to their female counterparts (Gerst et al., 2011; Mair et al., 2010). In particular, for elderly Mexican-American men, increased ethnic density was associated with decreased depressive symptoms, but this association did not hold for elderly Mexican-American women (Gerst et al., 2011). Increased depressive symptom severity among female ACS patients may also be related to neighborhood social factors (e.g., increased female headed households; Denton et al., 2014) and CVD factors (atypical ACS symptoms; Newman et al., 2013). Thus, it is critical to examine the possible moderating influence of gender on the Hispanic ethnic density-depression association.

Similarly, nativity status has consistently been found to be negatively associated with depressive symptoms, such that foreign-born individuals are less likely than US-born individuals to experience depressive symptoms (Alegría et al., 2008; Vega et al., 1998; Grant et al., 2004, Denton et al., 2014). These findings are consistent with the *immigrant paradox*, which refers to the relatively healthy status of foreign-born individuals despite their having increased health risk factors (Ronellenfitsch & Razum, 2004). Residential patterns show that Hispanics live in neighborhoods with high concentrations of immigrants, ranging from 12.1 to 48.6 % (US census, 2006 summary). Immigrant individuals typically have fewer economic resources (Mintz & Schuartz, 1964; Halim et al., 2013), and may face less familiarity with the health care system, which can result in compromised patient-physician communication and trust, and subsequently poor health outcomes. This lack of familiarity is particularly problematic given the ongoing involvement with healthcare associated with recovery from ACS. Further, immigrants may have less access to medical resources and treatment than non-immigrants. The influence of social dis/advantage may thus vary within foreign-born and US-born residents living in high Hispanic density neighborhoods.

To our knowledge, there are no prospective studies on the association of ethnic density with depressive symptoms in a sample of patients with CVD generally and ACS in particular. In conjunction with the inconsistent findings of Hispanic ethnic density on depression, we examined the prospective and potential change effects of Hispanic ethnic density on subsequent depressive symptom severity and the neighborhood characteristics that may be related to Hispanic ethnic density in a sample of 252 patients with ACS. Given the high correlation between ethnic density and area-level deprivation (Ostir et al., 2003; Gerst et al., 2011; Das-Munshi et al., 2010; Yuan et al., 2007), we consider area-level neighborhood characteristics, such as residential density (number of households within a census tract), neighborhood median income, and percentage of households receiving public assistance. Consistent with our previous findings, and contrary to the Ethnic Density hypothesis, we hypothesize a risk effect for Hispanic women, but not men, with ACS, living in neighborhoods with greater concentrations of Hispanics 1 year after their ACS event. Given the clinical vulnerability of our sample and the prospective research design, we will examine if ethnic density predicts change in depressive symptoms. Additionally, based on the aforementioned literature, we hypothesize that foreign-born Hispanic ACS patients, in contrast to those born within the US, will have decreased depressive symptoms, in spite of decreased neighborhood economic resources (public assistance, income, residential density).

Methods

The present study includes a subsample of 326 Hispanic patients enrolled in the Prescription Usage, Lifestyle, and Stress Evaluation (PULSE) study, a prospective cohort study of the prognostic risk conferred by depression following an ACS. Between February 1, 2009 and June 30, 2010, 1047 patients with unstable angina, acute ST-segment myocardial infarction (MI), or non-ST segment elevation MI were recruited within 1 week of their hospitalization for an index ACS event. The institutional review board of Columbia University Medical Center approved the study, and patients provided written informed consent. The baseline analyses are based on 326 patients, of which 49 % had unstable angina, 35 % had non-ST segment elevation MI, and 16 % had acute ST segment MI. Event status was adjudicated by two independent, board-certified cardiologists. Four patients died prior to the 1-year follow-up and 70 did not answer enough items to justify a regression-based approach to impute their total scores from the subset of answered items; as such, the sample size for the prospective analyses was 252 (77 % of the initial sample). There were no significant differences between the baseline and 1-year follow-up samples on demographic, clinical, or neighborhood characteristics.

Hispanic ethnic density was the primary independent variable. Hispanic ethnic density was defined as the percentage of Hispanics living within a census tract. Using Arc Geographic Information Software (ArcGIS^{SM}), each patient's mailing address was assigned to a census tract. Estimates of Hispanic ethnic density were extracted from Census American Community Survey 2011–2013 and matched to each patient-assigned census tract (Mason et al., 2011). Patient-reported addresses matched with 100 % spelling sensitivity to ArcGIS^{SM} database addresses. The baseline sample of 326 patients, were distributed across 317 census tracts from the New York, New Jersey, Connecticut and Pennsylvania region. On average, each census tract was populated by 6815 people. Census tracts ranged from 0 % Hispanic to 92.5 % Hispanic (predominantly Dominican). Of the 74.1 % Hispanic ethnic composition surrounding Columbia University Medical Center (Washington Heights, NY), the area in which the majority of patients resided, 66 % are Dominican; 7.1 % are Puerto Rican, 7.2 % are Mexican, 2.2 % are Cuban, 2.7 % are Central American, and 6.4 % are South American (Census, 2013).

Neighborhood measures of socioeconomic status (SES)

Government assistance, crowding, and income are associated with Hispanic ethnic density (Shaw et al., 2012), and may also be associated with depression (Matheson et al., 2006). As such, we assessed the following potential neighborhood-level confounds using data from the Census American Community Survey 2010–2013: (1) percentage of households receiving general and/or temporary financial assistance (Temporary Assistance to Needy Families; TANF); (2) residential density, defined as the total number of households within a given census tract; and (3) median household income per census tract as extracted from the 2010 US census.

Demographic factors

Demographic factors were assessed via interview during patients' index hospitalization for ACS. These factors included age, gender (male or female), education level (number of years completed in school), nativity status (US-mainland born or foreign-born), and English fluency ("If you do not consider English your first language, how well do you speak English?" (0, not at all; 1, poorly; 2, fairly well; 3, well; 4, very well).

CVD risk factors

CVD risk factors were ascertained from medical chart review. The Charlson Comorbidity Index—an index calculated as the weighted sum of 22 medical conditions—assesses a patient's CVD severity (Charlson et al., 1987). The Global Registry of Acute Coronary Events (GRACE) risk score is a post-discharge prediction model for 6-month mortality in ACS patients, with higher scores indicating greater mortality risk (Granger et al., 2003). Left ventricular ejection fracture [LVEF] was assessed by echocardiography, ventriculography, or nuclear stress testing.

Depressive symptoms

Our primary dependent variable was 1-year follow-up depressive symptom severity. Baseline and 1-year depressive symptom severity was measured using the 21-item self-report Beck Depression Inventory (BDI). Higher scores indicate greater depressive symptoms (Beck et al., 1961). We subtracted baseline BDI scores from 1-year BDI scores to compute the change in BDI variable. A validated Spanish version of the BDI was used as needed. The internal consistency of the BDI at baseline and 1-year follow-up was 0.90 and 0.93, respectively.

Analytic plan

All analyses were performed using SPSS 21. Baseline demographic, cardiovascular, and neighborhood factors are presented and compared by tertile of Hispanic ethnic density using analysis of variance for continuous variables and Chi square tests for categorical variables. Next, we examined the interrelations among these factors, ethnic density, and 1-year depressive symptom severity. We report the significant differences by gender and nativity status on demographic, cardiovascular and neighborhood factors. We describe ACS patients depressive symptom score change, 1-year post ACS discharge. To test our primary hypothesis, we used multivariable linear regression analyses and examined the main effect of Hispanic ethnic density on 1-year depressive symptom severity. Associations between ethnic density and depressive symptoms may be non-linear; for example, the effect of neighborhood (macro-level) factors on depressive symptoms may only become apparent above a certain ethnic concentration (Mair et al., 2010). In order to determine whether the association between Hispanic ethnic density and depressive symptoms was linear, we used scatter plots and skew statistics to look at the shape of the association and test for non-linearity. We assess non-linearity (quadratic effect) by squaring Hispanic ethnic density. To test whether gender and/or nativity status were moderators of the association of Hispanic ethnic density with 1-year depressive symptom severity, we included the cross-product of these terms with Hispanic ethnic density in two additional regression models. Block 1 adjusted for demographic factors (age, gender, nativity status, years of education, English language fluency); block 2 additionally adjusted for CVD risk factors (Charlson Comorbidity Index, LVEF, GRACE prognostic risk factor score, and baseline depressive symptom severity); and block 3 adjusted for neighborhood SES factors (median income, households receiving public assistance, residential density [linear term], and Hispanic density). In the final step of each model, we included the curvilinear (quadratic) effect of Hispanic ethnic density (Hispanic density squared) and the cross-product of the linear Hispanic ethnic density factor with each potential moderator. Last, we repeated the aforementioned analyses substituting the BDI change score for the 1-year BDI score to examine if Hispanic ethnic density significantly predicted change in depressive symptoms following an ACS event.

The variance between census tracts compared to the variance within census tracts was relatively small (intraclass correlation <0.001), and most (75.8 %) census tracks had fewer than five patients; therefore, we did not conduct multilevel regression analyses to adjust for clustering of data (Tabachnick & Fidell, 2007; Cohen et al., 2013). Because neighborhood factors represent interrelated living conditions, we examined collinearity statistics in the primary analyses. Tests for multicollinearity indicated a low level of multicollinearity in all analyses (VIF < 2.03), and no other assumptions of multivariable regression models were violated.

Results

Socio-demographic and neighborhood characteristics

The sample consisted of predominately male (61 %) and foreign-born (80 %) individuals, who reported speaking English "fairly well" and completed a mean of 10.4 (±4.4) years of education (Table 1). On average, patients lived among 56.1 % (±26.6 %) other Hispanics within their census tract. Patients living in census tracts in the highest tertile of Hispanic density (>71.5 % Hispanic) did not significantly differ from those living in census tracts with moderate (47.4–71.5 %) or low Hispanic density (< 47.4 %) on age ($p > 0.47$), cardiovascular ($p > 0.30$) or depression health characteristics ($p > 0.29$) (Table 2). In contrast, Hispanic ACS patients living in census tracts in

Table 1 Descriptives, individual- and-neighborhood level characteristics by gender and unadjusted associations of individual and neighborhood characteristics with 1-year depressive symptoms among 252 Hispanic participants with acute coronary syndrome

Individual-and-neighborhood level characteristics	Total sample mean (SD) unless otherwise noted	Male mean (SD) or N (%)	Female mean (SD) or N (%)	Bivariate correlation with 1-year BDI score	Bivariate correlation with Δ BDI score
Demographic factors					
Age	61.4 (11.0)	60.7 (11.4)	62.6 (10.4)	−0.14*	−0.14*
English fluency	1.9 (1.5)	2.0 (1.5)	1.9 (1.6)	0.04	−0.01
Education (years)	10.4 (4.4)	10.8 (4.6)	9.8 (3.9)*	−0.22	0.03
Foreign-born	261 (80.1)	162 (62.1)	99 (37.9)	0.05	0.05
Male sex, *N* (%)	199 (61 %)	–	–	0.20**	0.20**
Cardiovascular factors					
Charlson comorbidity index	1.7 (1.7)	1.4 (1.5)	2.1 (1.9)**	0.19**	−0.12
Left ventricular ejection fraction	50.3 (12.6)	49.1 (12.4)	52.2 (12.6)*	0.03	0.15*
GRACE prognostic risk score	89.6 (30.0)	88.7 (29.2)	91.1 (31.4)	−0.12	−0.24**
Baseline BDI score	9.2 (8.2)	6.7 (5.9)	12.8 (10.0)**	0.63**	−0.45**
1-year BDI score	7.1 (8.2)	5.5 (6.2)	9.5 (10.0)**	–	0.41**
Neighborhood SES factors					
Median income ($)	41,556 (24,483)	41,251 (21,411)	42,029 (28,686)	−0.09	−0.03
Households receiving public assistance (%)	6.3 (4.5)	6.4 (4.5)	6.1 (4.4)	0.01	0.01
Hispanic density (%)	56.1 (26.6)	55.7 (26.5)	56.7 (26.6)	0.08	−0.02
Residential density (N)	2308.2 (955.7)	2318.4 (942.6)	2292.5 (979.3)	−0.06	−0.004

GRACE global registry of acute coronary events, *BDI* beck depression inventory

* $p < 0.05$; ** $p < 0.01$

the highest tertile of Hispanic density had significantly less education and lower median income, received more public assistance, and resided in more residentially dense neighborhoods compared to those living in census tracts in the bottom two tertiles of Hispanic density. In the lowest tertile of Hispanic ethnic density, we observed an average 2.6 BDI score (±5.4) decrease in depressive symptoms over the 1 year follow-up period, as compared to a 2.3 (±5.5) and 1.9 (±7.7) BDI score decrease in depressive symptoms, in moderate and high Hispanic ethnic density neighborhoods, respectively ($p > 0.85$).

Neighborhood factors were intercorrelated. Neighborhood median income was significantly negatively related to households receiving public assistance ($r = -0.60$, $p < 0.001$), residential density ($r = -0.22$, $p < 0.001$), and Hispanic ethnic density ($r = -0.62$, $p < 0.001$). Residential density was independent of households receiving public assistance ($p > 0.53$). Hispanic ethnic density was positively correlated with residential density and percentage of households receiving public assistance ($r = 0.48$, $p < 0.001$ and $r = 0.44$, $p < 0$ 001, respectively).

Gender and nativity status differences

Hispanic male ACS patients had significantly more years of education (10.8 ± 4.6) compared to Hispanic female ACS patients (9.8 ± 3.9, $p = 0.05$). Female ACS patients had greater Charlson Comorbidity Index scores, baseline and 1-year depressive symptom severity scores, when compared to men. There were no observed gender differences on neighborhood-level factors.

At baseline, the average BDI score for the overall sample was 9.2 (±8.2), which is below the CVD operational definition of depression (BDI > 10; Lichtman, 2014, Grace et al., 2005, Hosseini et al., 2011, Davidson et al., 2010). At baseline, the female mean depressive symptoms score was 12.8 (±10.0) while the male mean depressive symptom score was 6.7 (±5.9). Using a paired sample *t* test, there was a small, but statistically significant reduction in depressive symptoms in the overall sample following an ACS event (baseline BDI score = 9.2 (8.2); 1-year BDI score = 7.1 (8.2); $t = 4.5$, $p < 0.001$). Notably, females reported more change in depressive symptoms

Table 2 Descriptives for demographic, clinical, and neighborhood factors by tertile Hispanic ethnic density among 252 Hispanic participants with acute coronary syndrome

Demographic, clinical, and neighborhood factors	Low density Mean (SD) or N (%)	Moderate density Mean (SD) or N (%)	High density Mean (SD) or N (%)	*p*
Demographic factors				
Age	61.5 (9.8)	62.9 (11.2)	60.9 (11.1)	0.47
Male	20 (10.1)	40 (20.1)	139 (69.8)	0.76
English fluency	2.7 (1.6)	2.7 (1.4)	1.6 (1.4)	<0.001
Education (years)				
Foreign-born	11.8 (4.1)	11.9 (3.6)	9.8 (4.5)	<0.001
Cardiovascular factors	18 (6.9)	49 (18.8)	194 (74.3)	0.002
Charlson comorbidity index	2.1 (1.7)	1.7 (1.8)	1.6 (1.7)	0.33
Left ventricular ejection fraction	53.0 (12.2)	51.4 (12.9)	49.6 (12.5)	0.30
GRACE prognostic risk score	88.5 (28.7)	89.0 (32.2)	90.0 (29.7)	0.95
Baseline BDI score	8.1 (7.1)	9.0 (7.9)	9.6 (8.5)	0.62
Neighborhood SES factors				
Median income ($)	96,709 (45,184)	54,255 (24,594)	32,931 (9560)	<0.001
Households receiving public assistance (%, SD)	1.3 (1.7)	4.2 (4.9)	7.4 (4.0)	<0.001
Hispanic density (%, SD)	5.2 (3.0)	24.0 (8.9)	70.3 (14.4)	<0.001
Residential density (N, SD)	1674.1 (599.6)	1729.6 (787.6)	2536.4 (930.7)	<0.001
1 year BDI score	5.0 (5.0)	6.3 (7.7)	7.5 (8.6)	0.29
Δ BDI score	−2.6 (5.4)	−2.3 (5.5)	−1.9 (7.7)	0.86

p values are based on the analysis of variance for continuous measures

p values are based on the χ^2 test for categorical measures

GRACE global registry of acute coronary events, *BDI* beck depression inventory

over the 1-year period than male Hispanic patients (female mean change in BDI scores = −3.3 (±8.8), male mean change in BDI scores = −1.2 (±5.6), t = 2.1, $p = 0.03$).

Foreign-born ACS patients were older, less educated, and spoke less English when compared to US born ACS patients ($p < 0.005$). Foreign-born ACS patients also had significantly less SES resources than their US born counterparts ($p < 0.04$), but there were no observed differences on CVD factors or depressive symptoms ($p > 0.24$, with exception to GRACE prognostic risk score [$p = 0.03$]). Changes in BDI scores over the 1-year period did not significantly differ by nativity status ($p > 0.68$).

Primary analyses

To test our main hypothesis, we regressed 1-year post-ACS depressive symptom severity scores on linear and curvilinear Hispanic density terms. In all models, the quadratic effect of Hispanic ethnic density was longitudinally related to depressive symptom severity. The measure of effect for the linear association between Hispanic ethnic density and 1-year depressive symptoms yielded an R^2 of 0.008 while the quadratic association between Hispanic ethnic density and 1-year depressive symptoms yielded an R^2 of 0.026. Relative to testing a linear ethnic density effect, the quadratic effect was a better fit for our data.

As shown in Table 3 (Model 2), demographic and CVD risk factors predicted 44.7 % of the variance in 1-year depressive symptom severity variance (R = 0.67, F (9, 200) = 18.02, model $p < 0.001$), and an additional 3.2 % of 1-year depressive symptom severity was explained by neighborhood factors (R = 0.69, F (14, 195) = 12.83, model $p < 0.01$, Δ F = 2.38, $p = 0.04$). In the fully-adjusted model, Hispanic ethnic density (squared and linear terms) explained 2.4 % of 1-year depressive symptom severity variance. Above and beyond demographic, CVD risk factors, and neighborhood characteristics, results showed a significant and negative curvilinear main effect of Hispanic ethnic density on 1-year post-ACS depressive symptoms (B = −0.002, β = −0.76, t(B) = −2.88, 95 % CI (B) = −0.004 to −0.001, $p = 0.004$) (see Model 3, Table 4). As shown in Fig. 1, this effect suggests that the magnitude of depressive symptoms among patients at the extremes of ethnic density (living in census tracts at lowest and highest tertile of Hispanic ethnic density) are more similar when compared to the magnitude of depressive symptoms among patients living in moderate Hispanic ethnic density census tracts. Visual inspection of the plot

Table 3 Multivariable Regression summary of the effect of baseline demographic, clinical, and neighborhood predictors, Hispanic ethnic density as an independent predictor, on 1-year depressive symptoms, Post-ACS

	Δ R^2	B	SE (B)
Model 1	0.103**		
Age		0.03	0.07
Gender (1 = male; 2 = female)		−0.06	0.99
Nativity status (1 = yes; 0 = no)		0.20	1.29
Years of education		−0.10	0.13*
English language fluency		0.11	0.39
Model 2	0.344**		
Charlson comorbidity score		0.48	0.30
LVEF		0.02	0.04
GRACE		−0.08	0.03*
Baseline depression severity		0.62	0.06**
Model 3	0.032*		
Median income		0.000025	0.000029
Households receiving public assistance		−0.07	0.14
Residential density		−0.001	0.001
Hispanic ethnic density		0.27	0.09*
Hispanic ethnic density^2		−0.002	0.001*

GRACE = prognostic risk factor * $p < 0.05$; ** $p < 0.001$

Table 4 Regression analyses testing gender as a moderator of the relationship of Hispanic ethnic density to 1-year depression in Hispanic post-ACS patients (N = 252)

	Adjusted Model 1				Adjusted Model 2				Adjusted Model 3			
	B	SE	β	R^2	*B*	SE	β	R^2	*B*	SE	β	R^2
Full sample												
Hispanic density to depression	0.21	0.09	0.66		0.22	0.07	0.68		0.27	0.09	0.85	
Hispanic density^2 to depression	−0.002	0.001	−0.60	0.10*	−0.002	0.001	−0.67	0.45**	−0.002	0.001	−0.76	0.48**
Full sample with interactions												
Gender	0.92	3.9	0.06		−4.58	3.31	−0.27		3.49	1.74	0.21	
Hispanic density^2	0.003	0.002	0.94		0.004	0.002	1.40		0.005	0.002	1.45	
Hispanic density^2 × gender	−0.003	0.002	−1.87	0.14*	−0.005	0.001	−2.51	0.51**	−0.005	0.001	−2.74	0.52***
Follow up analysis												
Male (Hispanic density^2 to depression)	<0.001	0.001	−0.13	0.08	−0.000006	0.001	−0.03	0.40	<0.001	0.001	−0.10	0.41
Female (Hispanic density^2 to depression)	−0.004	0.002	−0.97	0.12*	−0.005	0.001	−1.2	0.57**	−0.006	0.002	−1.50	0.58**

Adjusted Model 1 included age, gender, education, nativity status, and English fluency. Adjusted $R^2 = 8.1$ %

Adjusted Model 2 included covariates in Model 1, Charlson comorbidity index, LVEF, GRACE risk score, and baseline depressive symptoms. Adjusted $R^2 = 42.3$ %

Adjusted Model 3 included covariates in Model 1, Model 2, median household income, % households receiving public assistance, and residential density. Adjusted $R^2 = 44.2$ %

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

shows that the association of Hispanic ethnic density and depressive symptom severity was positive for patients in census tracts with 0–60.0 % density; depressive symptoms appeared to reach a relative peak for patients living in census tracts with greater than 60–70 % Hispanic ethnic density. A negative association emerges for patients living in census tracts with greater than 75 % Hispanic ethnic density, such that greatest Hispanic ethnic density was associated with lower depressive symptom severity (Fig. 1).

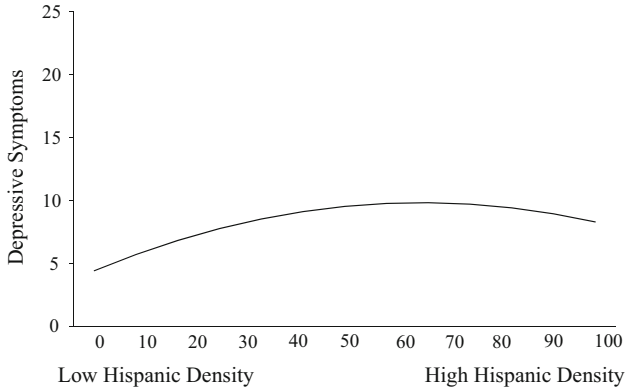

Fig. 1 Curvilinear (non-linear) effect between Hispanic ethnic density and one year depressive symptoms among Hispanic ACS patients (N = 252). Plot depicts fully adjusted regression model, which includes demographic, cardiovascular (including baseline depressive symptoms), and neighborhood level predictors

We next explored how much of the ACS depressive symptom score change in 1 year is explained by patients living in Hispanic ethnic density neighborhoods. In a fully adjusted model, Hispanic ethnic density (squared and linear terms) explained an additional 3.2 % of depressive symptom change (Δ F = 4.50, $p = 0.01$). Adjusting for all covariates, both linear (B = 0.27, $\beta = 0.98$, 95 % CI (B) = 0.09 to 0.45, $p = 0.003$) and curvilinear (B = −0.002, $\beta = -0.87$, 95 % CI (B) = −0.004 to −0.001, $p = 0.004$) Hispanic ethnic density terms independently predicted change in depressive symptom severity, 1-year following an ACS event. Further, both linear (B = 0.45, $\beta = 3.08$, 95 % CI (B) = 0.17 to 0.74, $p = 0.002$) and curvilinear (B = −0.005, $\beta = -3.15$, 95 % CI (B) = −0.008 to −0.002, $p < 0.001$) Hispanic ethnic density main effects on depressive symptom change were significantly moderated by gender.

Contextual modifiers

We next tested whether gender moderated the Hispanic ethnic density and depressive symptom severity association (Table 4). In Model 1 (adjusted for demographic factors only), we observed a significant interaction of gender by the curvilinear Hispanic ethnic density term on 1-year depressive symptom severity (B = −0.003, $\beta = -1.87$, 95 % CI (B) = −0.004 to −0.001, $p = 0.04$); the interaction effect with the linear Hispanic ethnic density term did not reach statistical significance (B = 0.29, $\beta = 0.09$, 95 % CI (B) = −0.02 to 0.07, $p = 0.20$). After further adjustment for cardiovascular disease risk factors (Model 2), there remained a significant interaction effect of gender by linear Hispanic ethnic density (B = 0.40, $\beta = 2.36$, 95 % CI (B) = 0.12 to 0.68, $p = 0.005$) and gender by curvilinear Hispanic ethnic density (B = −0.005, $\beta = -2.51$, 95 % CI (B) = −0.007 to −0.002, $p = 0.001$) on 1-year depressive symptom severity. In the fully-adjusted model (Model 3), gender significantly moderated the relation between Hispanic ethnic density (as both a linear [B = 0.45, $\beta = 2.68$, 95 % CI (B) = 0.17 to 0.74, $p = 0.002$] and curvilinear term [B = −0.005, $\beta = -2.74$, 95 % CI (B) = −0.008 to −0.002), $p < 0.001$]) and 1-year depressive symptom severity. Female patients who lived in census tracts with high Hispanic ethnic density experienced a significant increase in depressive symptom severity with increasing Hispanic ethnic density (as both a linear [B = 0.62, $\beta = 1.52$, 95 % CI (B) = 0.26 to 0.99, $p = 0.001$] and curvilinear effect [B = −0.006, $\beta = -1.50$, 95 % CI (B) = −0.009 to −0.003), $p = 0.001$]), with symptoms reaching a BDI score ≥ 10 in census tracts with greater than 70 % Hispanic ethnic density. Although we observed an association of greater Hispanic ethnic density with greater 1-year depressive symptom severity among men, the effect was neither statistically significant ($p > 0.79$) nor linear (Fig. 2).

Finally, we tested the moderating effect of nativity status on the association of Hispanic ethnic density with depressive symptom severity. Nativity status did not significantly moderate the linear (B = 0.19, $\beta = 0.70$, 95 % CI (B) = −0.23 to 0.60), $p = 0.38$) or curvilinear (B = −0.002, $\beta = -0.70$, 95 % CI (B) = −0.01 to 0.003), $p = 0.40$) association between Hispanic ethnic density and 1-year depressive symptom severity.

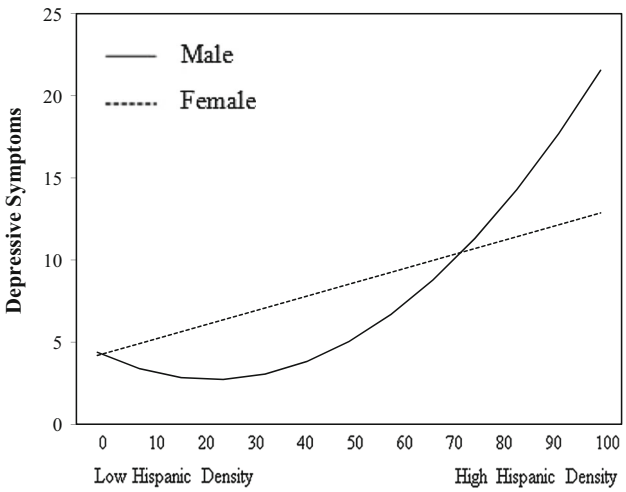

Fig. 2 Both linear and curvilinear effect between Hispanic ethnic density and 1 year depressive symptoms, moderated by Gender, among Hispanic ACS patients (N = 252). Plot depicts fully adjusted regression model, which includes Hispanic ethnic density, the squared term of Hispanic ethnic density, Hispanic ethnic density × gender, squared Hispanic ethnic density × gender, demographic, cardiovascular (including baseline depressive symptoms), and neighborhood level predictors

Discussion

In this study we considered the impact of Hispanic ethnic density on depressive symptom severity 1 year following an ACS event. Hispanic ethnic density was associated with greater depressive symptom severity, above and beyond traditional CVD risk factors, among Hispanic patients with ACS. Our findings summarize a curvilinear association between Hispanic ethnic density and future depressive symptoms, such that Hispanic ethnic density is increasingly less beneficial at moderate to high ethnic concentrations, relative to the lowest and highest Hispanic ethnic densities, in our general sample. Moreover, our results show that gender significantly moderated the relation between Hispanic ethnic density and 1-year depressive symptom severity. Specifically, Hispanic female ACS patients displayed a relatively steady increase in depressive symptom severity as Hispanic ethnic density increased, which is consistent with the general and increased likelihood for women to experience depression. In contrast, the association of Hispanic ethnic density and depressive symptom severity among Hispanic men was non-statistically significant and non-linear.

Considering the clinical vulnerability of an ACS sample and the contextual exploration of Hispanic health outcomes, we examined if a patient's neighborhood contributes to changes in depressive symptoms over time. Overall, Hispanic ethnic density was associated with the magnitude of change in depressive symptoms, over time. Relatively greater symptom reduction was observed in less ethnically dense neighborhoods when compared to high ethnically dense neighborhoods and among female versus male ACS patients. We observe minimal changes in depressive symptoms related to neighborhood ethnic density (maximum BDI score reduction of 3). A mean percent reduction of 7.7 % was observed in patients' BDI score, 1-year post-ACS, which corresponds with a small effect size change of 0.26 (Cohen's D). We consider these effects to be clinically meaningful, as there is research evidence of a dose–response association between depressive symptoms and cardiac risk (Lespérance et al., 2002). Indeed, after a heart attack, a significant and small decrease in depressive symptoms demonstrates some prognostic benefit. Thus, the reduction in depressive symptoms associated with neighborhood ethnic density reflects a clinically meaningful post-ACS advantage.

Overall, as Hispanic ethnic density increased from low to moderate density, there was an increase in depressive symptoms among Hispanic ACS patients. This positive trend peaked in moderate-to-high Hispanic density neighborhoods, yet appears to slightly decline in census tracts with the highest density of Hispanics. The heterogeneous and non-linear effect of Hispanic ethnic density on depressive symptoms may reflect an uneven distribution of neighborhood disadvantage across high, moderate, and low-density neighborhoods. Because of the variability of neighborhood financial and social resources, ACS patients may have relatively compromised access to both psychological and physical health interventions independent of Hispanic residential density. Given these findings, practitioners may want to discuss the implications of neighborhood factors on health with Hispanic ACS patients. Specifically, practitioners may want to inquire about neighborhood stressors, nearby and practical aids to treatment adherence (e.g. counseling, preventative health programs etc.), and utilization of neighborhood health resources related to recovery after an ACS event.

To our knowledge, our study is the first to provide evidence of a differential effect of gender on the curvilinear association of Hispanic ethnic density with depressive symptoms and depressive symptom change. The observed change in the direction of the effect, from slightly protective to detrimental, Hispanic ethnic density on depressive symptoms in men, contrasted with a steady increased risk of depressive symptoms for women living in neighborhoods with increasing Hispanic ethnic density, denotes a differential impact of neighborhood on mental health outcome by gender. The increased risk of depressive symptoms for women living in high ethnic concentrations has been documented among Hispanics. For example, the Multi-Ethnic Study of Atherosclerosis (MESA) followed 608 Hispanic women over a 10-year period and found that Hispanic women living in areas with more Hispanic residents tended to have higher depressive symptoms scores, although a drop was observed in the highest quartile (Mair et al., 2010). A similar pattern was not observed among Hispanic men in the MESA study. The data suggest a more complex relationship between neighborhood social resources (or lack thereof) and depression for female Hispanic residents relative to male Hispanic residents, living in neighborhoods with a similar Hispanic ethnic concentration. Indeed, Stafford et al. (2011) summarize that when considering neighborhood characteristics, such as social ties, unemployment, and trust, the magnitude of association between neighborhood characteristics and self-reported health outcomes was consistently greater among women, when compared to men. More broadly, when we consider the impact of neighborhood on individual mental health outcomes, among women, we begin to identify the complex interrelations between neighborhood, mental health symptoms, and cardiovascular health. The Women's Health Initiative followed approximately 70,000 women over a 16-year period to examine the association between social strain (negative social relationships), depression,

incident CHD and stroke (Kershaw et al., 2014). Study results showed a significant association of social strain (adjusted for depressive symptoms) on higher incident CHD and stroke (Kershaw et al., 2014). Although our results show that women reported more depressive symptoms, at baseline, they experienced a greater reduction in depressive symptoms, post-ACS, when compared to men. Our findings are consistent with studies that link social experience within a neighborhood and women's mental and physical health outcomes (Cutrona et al., 2005, 2006; Barrington et al., 2014).

Although this is the first prospective study to document an independent and long-term association between Hispanic ethnic density and depressive symptom severity, and thus the first study to rule out a reverse-causation effect between ethnic density and depression, such as, depressed ACS patients choosing to live in neighborhoods with greater density and deprivation (Mair et al., 2008), there are some limitations that warrant further discussion. First, the sample was compromised of vulnerable cardiac patients, who displayed initially low levels of depressive symptoms, which were below the clinical significance cut-offs. However, prior research has shown that even mild depressive symptoms (BDI $\geq$ 4) are associated with increased prognostic risk in cardiac patients (Bush et al., 2001). Second, the limited representation of US-born Hispanic ACS patients might have prevented our ability to detect significant nativity moderating effects. Future studies should explore further whether or not nativity status moderates the association between Hispanic ethnic density and depressive symptoms in a sample with adequate numbers of US-born and foreign-born Hispanics. Third, our patients were drawn from a single site where ACS patients were hospitalized in an urban academic medical center. Thus, our findings might not be generalizable to other ACS patients living in different geographic regions. Also, our findings are based on a sample of predominately Dominican individuals, and thus may be less representative of other Hispanic subgroups.

Conclusion

The results of the current study point to a complex relation between Hispanic ethnic density, gender, and depression among Hispanic patients after an ACS. Our findings suggest that the concentration of socioeconomic constraints (e.g., low-paying jobs, high level of poverty) in overcrowded neighborhoods may offset the potential social support/cohesion benefits incurred from living around ethnically similar individuals, which may potentially impact ACS recovery. Further, our results highlight how gender contributes to the magnitude and nature of the association of neighborhood-level factors and depression. Future work should consider how neighborhood assets and interventions designed to mitigate health disparities in Hispanic ethnic density neighborhoods can be used to leverage mental health promotion and ACS recovery.

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Compliance with ethical standards

Conflict of interest Ellen-ge D. Denton, Jonathan A. Shaffer, Carmela Alcantara, and Esteban Cadermil, declares that they have no conflict of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants for being included in the study.

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