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### Title

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### Permalink

<https://escholarship.org/uc/item/1tq3s69f>

### Journal

Journal of the American Heart Association, 7(19)

### ISSN

2047-9980

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### Publication Date

2018-10-02

### DOI

10.1161/jaha.118.009107

Peer reviewed

# County-Level Hispanic Ethnic Density and Cardiovascular Disease Mortality

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**Background**—Hispanics are the fastest growing ethnic group in the United States, and little is known about how Hispanic ethnic population density impacts cardiovascular disease (CVD) mortality.

**Methods and Results**—We examined county-level deaths for Hispanics and non-Hispanic whites from 2003 to 2012 using data from the National Center for Health Statistics' Multiple Cause of Death mortality files. Counties with more than 20 Hispanic deaths (n=715) were included in the analyses. CVD deaths were identified using *International Classification of Diseases, Tenth Revision (ICD-10)*, I00 to I78, and population estimates were calculated using linear interpolation from 2000 and 2010 census data. Multivariate linear regression was used to examine the association of Hispanic ethnic density with Hispanic and non-Hispanic white age-adjusted CVD mortality rates. County-level age-adjusted CVD mortality rates were adjusted for county-level demographic, socioeconomic, and healthcare factors. There were a total of 4 769 040 deaths among Hispanics (n=382 416) and non-Hispanic whites (n=4 386 624). Overall, cardiovascular age-adjusted mortality rates were higher among non-Hispanic whites compared with Hispanics (244.8 versus 189.0 per 100 000). Hispanic density ranged from 1% to 96% in each county. Counties in the highest compared with lowest category of Hispanic density had 60% higher Hispanic mortality (215.3 versus 134.2 per 100 000 population). In linear regression models, after adjusting for county-level demographic, socioeconomic, and healthcare factors, increasing Hispanic ethnic density remained strongly associated with mortality for Hispanics but not for non-Hispanic whites.

**Conclusions**—CVD mortality is higher in counties with higher Hispanic ethnic density. County-level characteristics do not fully explain the higher CVD mortality among Hispanics in ethnically concentrated counties. (*J Am Heart Assoc.* 2018;7:e009107. DOI: 10.1161/JAHA.118.009107.)

**Key Words:** enclaves • ethnicity • health disparities

Hispanics are the largest minority group in the United States and experience a disproportionate burden of cardiovascular disease (CVD) risk factors.<sup>1,2</sup> Despite this,

when studied in aggregate, Hispanics experience lower mortality rates when compared with non-Hispanic whites (NHWs). This lower-than-expected mortality, despite greater adverse CVD risk profiles and lower levels of income and education than NHWs, has been coined the “Hispanic paradox.”<sup>3–6</sup> Some have speculated that residence in enclaves may be protective for Hispanics by providing a place where more salubrious cultural habits are maintained (ie, improved nutrition and lower smoking rates).<sup>7</sup> Ethnic enclaves may also provide added social cohesion and support, which may partially account for the mortality advantage experienced by Hispanics.

As the Hispanic population in the United States continues to grow, there is also evidence of increasing residential segregation.<sup>8,9</sup> Hispanics are more likely to be exposed to neighborhood disadvantage, living in areas with higher rates of poverty and lower average incomes as compared with predominantly NHW neighborhoods.<sup>10</sup> Much work on segregation and cardiovascular health has focused on blacks and has shown that residential segregation has deleterious effects on health outcomes, including higher incidence of

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Accompanying Tables S1 and S2 are available at <https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.009107>

The abstract of this work was presented at the American Heart Association's Scientific Sessions, November 11 to 15, 2017, in Anaheim, CA.

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Received March 6, 2018; accepted July 19, 2018.

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## Clinical Perspective

### What Is New?

- Hispanics experience greater cardiovascular mortality in counties with high Hispanic ethnic density.

### What Are the Clinical Implications?

- Counties with high Hispanic density likely have worse access to care and other adverse environmental factors that lead to greater mortality.
- Public health and clinical efforts to improve outcomes for Hispanic patients need to target the counties where Hispanics are concentrated.

cardiovascular disease,<sup>11</sup> hypertension,<sup>12</sup> and likelihood to receive care for acute myocardial infarctions in hospitals with higher mortality rates.<sup>13</sup> Yet the data for the health effects of residential segregation for Hispanics are limited and mixed.<sup>11,14,15</sup> To our knowledge, no study has specifically assessed the impact of Hispanic ethnic density on CVD mortality using national, contemporary data including a diverse sample of US Hispanics.

Thus, the objective of this study was to explore the association between Hispanic ethnic concentration (Hispanic density) and cardiovascular mortality among Hispanics and NHWs. We tested the hypothesis that residence in ethnic enclaves would be protective for Hispanic cardiovascular mortality, even after adjusting for county-level demographic, socioeconomic, and healthcare-related characteristics.

## Methods

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure because our data set is restricted; however, these data are publicly available through the US Census Bureau should other investigators choose to obtain them.

## Outcome Measure

County-level deaths for Hispanics and NHWs were examined using the National Center for Health Statistics' Multiple Cause of Death mortality files from 2003 to 2012. To ensure that there would be sufficient counties as well as sufficient deaths in each county in the analyses, we included counties with more than 20 Hispanic CVD deaths during the study period (n=715). We then identified CVD mortality using *International Classification of Diseases, Tenth Revision (ICD-10)* codes for cardiovascular deaths (I00–I78) for Hispanic and NHW adults

over age 25. Population estimates were obtained from the 2000 and 2010 census data, and the midyear estimate of the study period was calculated using linear interpolation and extrapolation out to 2012. We calculated county-level directly standardized age- and sex-adjusted CVD mortality rates (AMRs) per 100 000 population for Hispanics and NHWs by 5-year age categories, as done in previous studies.<sup>16,17</sup>

## Predictor Variable and County-Level Covariates

The proportion of Hispanic adults by county was calculated from census records on the basis of linear interpolations methods from 2000 and 2010. County-level covariates were identified from the 2011 and 2012 County Health Rankings database, the census, and American Community Survey records (Table S1). The County Health Rankings and Roadmaps program (<http://www.countyhealthrankings.org/about-project>) collects data from different data sources and geolocates these data in order to provide a reliable and sustainable source of health information in US communities. We categorized the county-level covariates into 3 groups: demographic characteristics (total population size, Hispanic population size, NHW population size, Hispanic deaths, NHW deaths, proportion 18 years of age and younger, proportion 65 years of age and older, and proportion female), socioeconomic characteristics (median household income, proportion below the poverty line, education, proportion employed, proportion of blacks, limited English proficiency proportion, and rural), and healthcare factors (proportion uninsured and primary care physician ratio).

## Statistical Analysis

Because county Hispanic density is skewed, we categorized counties into 5 groups of Hispanic proportions using cut points based on a logarithmic scale for visual presentation: 1.38% to 2.71% (n=21), 2.72% to 7.38% (n=186), 7.39% to 20.08% (n=260), 20.09% to 54.60% (n=198) and, 54.61% to 96.10% (n=50). Directly standardized AMRs were further calculated for Hispanics and NHWs in each category. Kendall correlation was performed to test the increasing trend for Hispanic and NHW AMRs by categories of increasing Hispanic density. Descriptive statistics (mean and standard deviation) and general linear models were performed to compare the county-level characteristics among the categories. Before model selection, a correlation coefficient analysis was used to exclude collinear covariates. After testing assumptions for linear regression, including linearity, normality of the residuals, homoscedasticity, and multicollinearity, multivariable linear regression models were used to examine the association of Hispanic density as a continuous variable with Hispanic and NHW AMRs with adjustment of county-level

covariates. Because Hispanic ethnic density was not normally distributed, we performed a logarithmic transformation of this variable for all models. The base model included the county-level Hispanic density, population size, and proportion female. We excluded Hispanic and NHW population size and death counts from our final models due to the high collinearity with total population size.

We performed a sensitivity analysis using the Hispanic isolation index, a commonly used measure of metropolitan-level segregation.<sup>18,19</sup> The Hispanic isolation index measures the extent to which Hispanics in a county or metropolitan area are exposed only to other Hispanics (ie, isolated from other race/ethnic groups). It is a measure of exposure, one of the 5 dimensions of metropolitan-level segregation, and is computed as the minority-weighted average of the minority proportion in each area, with the NHW population as the referent group.<sup>19</sup> It ranges from 0 to 1, with higher values indicating less exposure of Hispanic individuals to NHWs.

All analyses were performed in R Studio (version 0.99.896) and SAS (version 9.4), and statistical tests were based on 2-sided tests with a significance level of 0.05. The map (Figure 1) was created using Tableau Desktop Public Edition

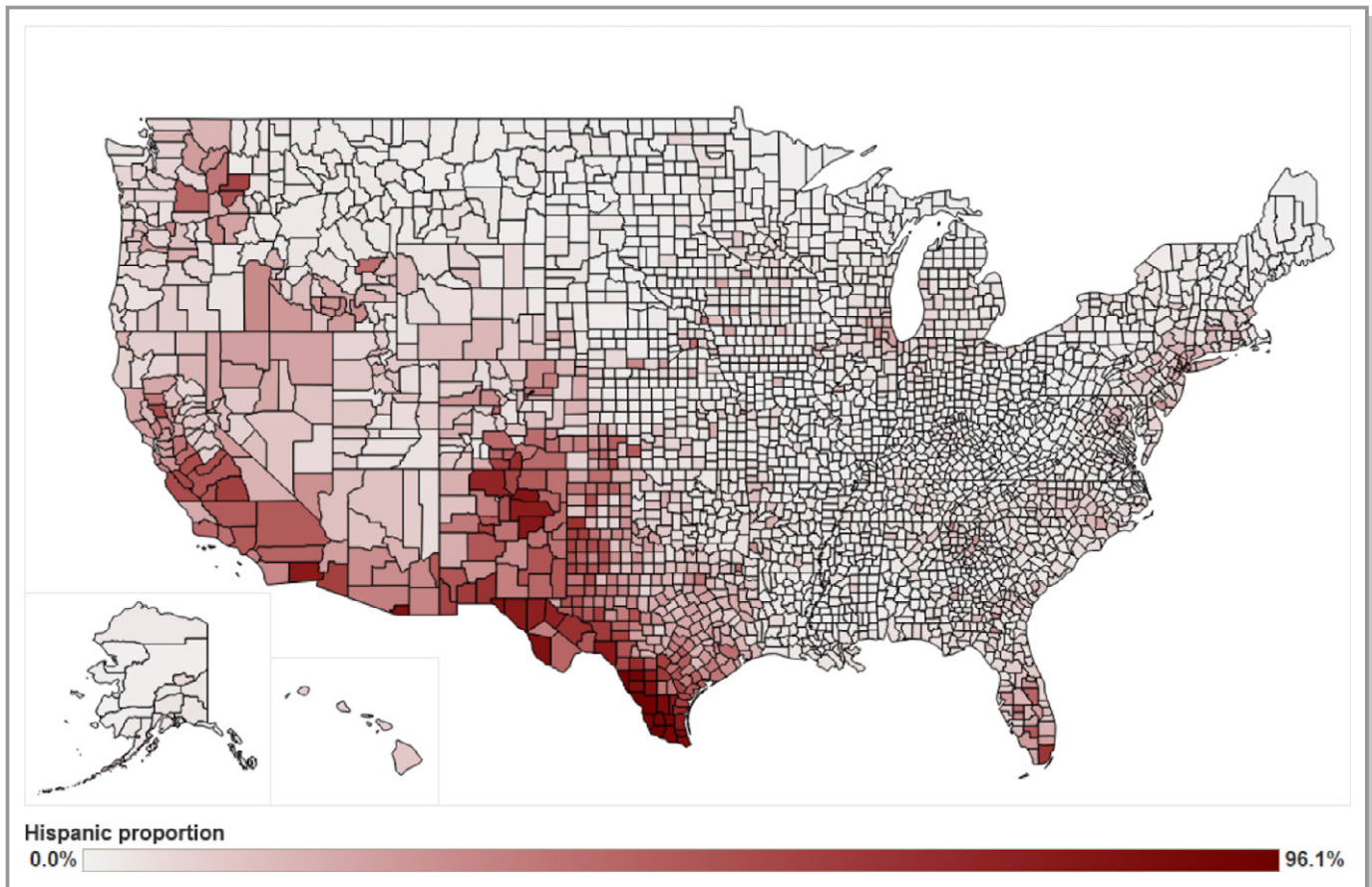
10.1.5 based on linear interpolation of 2000 and 2010 US census data.

The Institutional Review Board of Stanford University approved this study and provided a waiver for use of these publicly available mortality and US census data.

## Results

A total of 4 769 040 deaths occurred during our study period among Hispanics (n=382 416) and NHWs (n=4 386 624) within the 715 counties studies. Overall, cardiovascular AMRs were higher among NHWs compared with Hispanics (244.8 versus 189.0 per 100 000). The Hispanic proportion of each US county is shown in Figure 1. Counties with higher Hispanic density were predominantly located in the southwestern United States, southern Florida, and a few regions in the Northeast.

Table 1 shows county-level demographic characteristics, socioeconomic status, and healthcare factors by Hispanic density categories among the 715 counties. Hispanic density ranged from 1% to 96%. Counties with a higher Hispanic density were more likely to have greater socioeconomic disadvantage with a lower median household income, higher



**Figure 1.** Hispanic proportion of US counties from the 2000–2010 US census data.

**Table 1.** County-Level Demographic Characteristics, Social Economic Status, and Healthcare Factors by Hispanic Density Categories

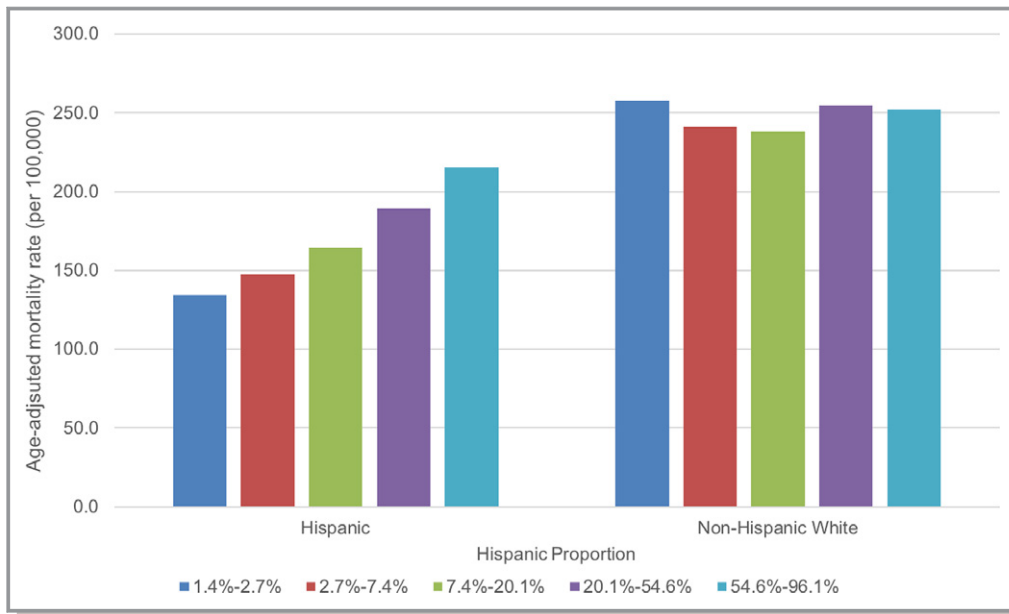
	Hispanic Proportion					P Value
	1.38%–2.71% (n=21)	2.72%–7.38% (n=186)	7.39%–20.08% (n=260)	20.09%–54.60% (n=198)	54.61%–96.10% (n=50)	
<b>Demographic characteristics, mean (SD)</b>						
Hispanic density, %	2.1 (0.4)	5 (1.3)	12.7 (3.7)	3.2 (10.3)	71.8 (13.6)	
Log-transformed Hispanic density	0.7 (0.2)	1.6 (0.3)	2.5 (0.3)	3.5 (0.3)	4.3 (0.2)	
Total population size, 100k	42.6 (30.9)	29.6 (27.1)	29 (34.1)	38.9 (98.9)	16.6 (42.8)	0.1033
Hispanic population size, 100k	0.9 (0.6)	1.5 (1.4)	3.7 (5.1)	13 (39.2)	11.5 (27.7)	<0.0001
NHW population size, 100k	33.7 (23.6)	21.7 (18.5)	18.7 (20.1)	17.2 (38)	3.5 (9.4)	0.0002
Hispanic deaths	49.8 (44)	74.4 (107.4)	223.1 (548.7)	1067.5 (3477.3)	1963 (5838.2)	<0.0001
NHW deaths	12 181.9 (10 043.4)	6795.3 (6406.2)	6008.8 (7096.6)	6245.2 (14 507.3)	1360.8 (3472.2)	<0.0001
Proportion 18 and younger	23 (2)	23.4 (2.5)	24.1 (3.4)	26 (3.7)	29 (4.5)	<0.0001
Proportion 65 and older	14.5 (2.7)	13.5 (3.7)	14 (4.5)	13.5 (4.3)	13.2 (2.9)	0.4372
Proportion female	51.4 (0.8)	51 (1)	50.3 (1.5)	49.4 (2.7)	49.9 (2.5)	<0.0001
<b>Social economic status</b>						
Median household income, 10k	5.4 (1.1)	5.4 (1.3)	5.5 (1.5)	4.7 (1.2)	3.6 (0.7)	<0.0001
Proportion below poverty line	8.5 (3.8)	8.9 (3.8)	9.3 (3.7)	12.4 (3.9)	20.4 (7.2)	<0.0001
High school graduation rate	80.5 (9.3)	78 (10.5)	77.1 (9.9)	72.9 (9.9)	68.9 (9.5)	<0.0001
Some college rate	63.5 (7.2)	63.1 (8.6)	58.5 (10.7)	49.3 (10.5)	41.7 (9.7)	<0.0001
Proportion unemployment	9.8 (3.1)	9.2 (2.6)	8.9 (2.5)	8.5 (3)	10.1 (4.4)	0.0026
Proportion black	12.9 (12.3)	12.8 (13.5)	9.7 (10.8)	6.5 (6.4)	2.6 (3.2)	<0.0001
Proportion not proficient in English	2 (1)	3.1 (1.6)	6.2 (3.5)	12.4 (6.2)	21.8 (11)	<0.0001
Proportion rural	15.8 (12.3)	22 (17.3)	28 (23.7)	33.3 (26.5)	33.3 (23.6)	<0.0001
<b>Healthcare factors</b>						
Proportion uninsured	14.7 (4.9)	16.5 (4.6)	20.6 (6.1)	27.2 (6.2)	32.4 (7.5)	<0.0001
Primary care physicians per 100 000 population	93 (40.5)	92.2 (47.4)	78.1 (42.4)	62.8 (36.6)	42.7 (29.1)	<0.0001

NHW indicates non-Hispanic white.

proportion below the poverty line, lower high school graduation rates, and a greater proportion of residents of limited English proficiency. Counties with high Hispanic density were also more likely to be rural. The proportion of uninsured county residents increased with increasing Hispanic ethnic density. Counties with the lowest Hispanic density had 78% more primary care physicians per 100 000 population compared with counties with the highest Hispanic density.

Age-adjusted CVD mortality of Hispanics and NHWs by Hispanic density categories is shown in Figure 2. Overall, there was a statistically significant graded increase in Hispanic CVD mortality as Hispanic proportion increased ( $P=0.0143$ ). However, Hispanic proportion was not significantly associated with mortality for NHWs ( $P=0.6242$ ). Counties in the highest compared with lowest category of Hispanic density had 60% higher Hispanic mortality (215.3 versus 134.2 per 100 000).

Table 2 provides the multivariable linear regression model results, adjusting for demographic (base model), socioeconomic, and healthcare factors separately, and then combined for both Hispanic AMRs and NHW AMRs. Socioeconomic and healthcare factors explained 37% and 26% of the county-level variation in Hispanic mortality and 30% and 10% for NHW mortality, respectively. The fully adjusted model accounted for 38% and 31% of the mortality variation for Hispanics and NHWs, respectively. Hispanic density had a stronger association with mortality among Hispanics as compared with NHWs ( $r^2=0.22$ ,  $P<0.0001$ ) than NHWs ( $r^2=0.01$ ,  $P=0.0461$ ) in the base model. In fully adjusted models, the mortality gradient for Hispanics in counties with higher Hispanic density remained unchanged. For each 1-unit increase in Hispanic density on the log scale, there was a 22.57 increase in age-adjusted mortality rates per 100 000 for Hispanics. The fully adjusted estimates are modeled in Figure 3, using the



**Figure 2.** Age-adjusted cardiovascular mortality rate (per 100 000) for Hispanics and non-Hispanic whites by Hispanic proportion.

midpoint value for each Hispanic ethnic density category and the mean value for other covariates. Adjusted models for Hispanic and NHW AMRs by Hispanic proportion including all available data points are presented in Figure 4.

In a sensitivity analysis, we used the Hispanic isolation index as the predictor (Table S2) for the multivariable linear regression models. The results were qualitatively similar.

### Discussion

Using a decade of national data, we found that Hispanic ethnic density is positively correlated with CVD mortality among both Hispanics and NHWs. However, this finding persisted for Hispanics after adjusting for county-level sociodemographic and healthcare factors. The finding that Hispanic ethnic density is associated with increased CVD

mortality is noteworthy and challenges existing notions about the protective effect of cultural enclaves among Hispanics.

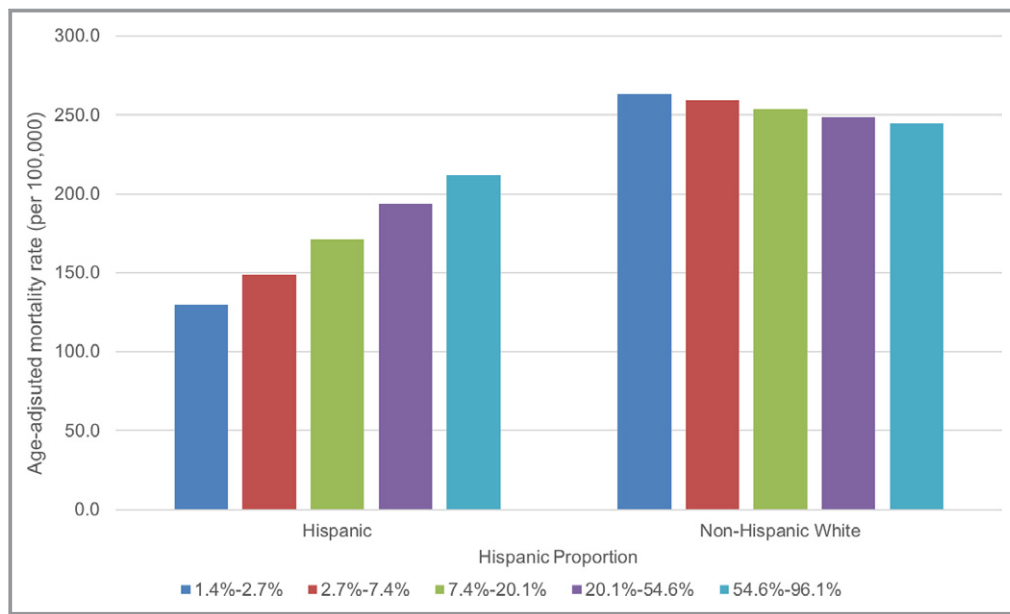
Prior work studying the effects of neighborhood segregation and CVD among Hispanics is limited and mixed. Studies have largely focused on CVD risk factor prevalence and self-reported health outcome measures.<sup>18,20,21</sup> While residential segregation has been linked with higher incidence of CVD among blacks, there was no association in incidence of CVD among Hispanics in the Multi-ethnic Study of Atherosclerosis.<sup>11</sup> Using the isolation index as a measure of residential segregation, Corral and colleagues found a positive association between Hispanic segregation and prevalence of obesity.<sup>22</sup> One study in Chicago found that although residential segregation was associated with lower odds of hypertension, individuals were less likely to regularly see physicians or take antihypertensive medications.<sup>23</sup> Neighborhoods with

**Table 2.** Multivariate Linear Regression Models for Hispanic and Non-Hispanic White Age-Adjusted Cardiovascular Mortality per 100 000 (Per 1-Unit Increase in Log Hispanic Ethnic Density)

Adjustment Variables	Hispanic AMR				Non-Hispanic White AMR			
	N	Change in AMR	P Value	R <sup>2</sup>	N	Change in AMR	P Value	R <sup>2</sup>
Base model	715	26.68	<0.0001	0.22	715	3.64	0.0461	0.01
Base model+SES*	706	19.96	<0.0001	0.37	706	-4.02	0.1296	0.30
Base model+healthcare factors	715	24.63	<0.0001	0.26	715	-4.86	0.0399	0.10
Fully adjusted model*	706	22.57	<0.0001	0.38	706	-5.20	0.0605	0.31

Base model: Hispanic proportion, population size and proportion female. SES: median household income, % under poverty line, % high school graduation, % some college, % unemployed, % black, % not proficient in English and % rural. Healthcare factors: % uninsured, primary care physician rate. Fully adjusted model: base model+SES+healthcare factors. AMR indicates age-adjusted mortality rates; SES, socioeconomic status.

\*Nine counties are missing high school graduation rate and are therefore not included in the SES adjusted models. These counties include Orleans, Marin, Richmond, Kings, New York, Queens, Bronx, Jeff Davis, and Yuma.



**Figure 3.** Modeled estimates of age-adjusted cardiovascular mortality rate (per 100 000) for Hispanics and non-Hispanic whites by Hispanic proportion. The model estimates include midpoint values of Hispanic density on log scale (1.9% for category 1, 4.5% for category 2, 12.2% for category 3, 33.1 for category 4, and 73.7 for category 5) and mean values were used for other covariates (population size, proportion female, median household income, % under poverty line, % high school graduation, % some college, % unemployed, % black, % not proficient in English and % rural, % uninsured and primary care physician rate).

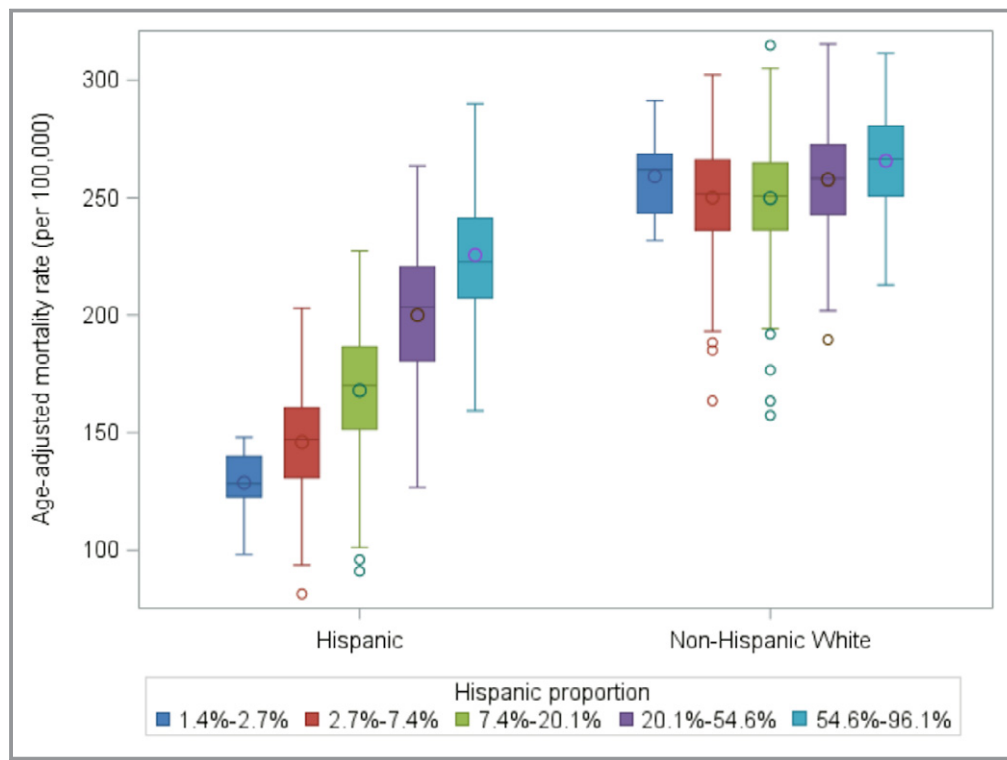
high Hispanic ethnic density have been linked with better diet but worse physical activity environments.<sup>7</sup>

Our findings have several possible explanations. Similar to blacks, Hispanics are likely to live in more deprived neighborhoods with higher poverty and lower availability of resources.<sup>24,25</sup> As documented in our study and others,<sup>11</sup> areas of high Hispanic segregation are associated with adverse socioeconomic conditions. Low neighborhood socioeconomic status has been associated with an increased risk of out-of-hospital cardiac death.<sup>26</sup> Furthermore, it is possible that residual confounding by unmeasured neighborhood or individual-level characteristics account for the higher mortality in counties with high Hispanic ethnic density, and that the previously hypothesized protective effects of cultural enclaves are unable to fully counter these effects. Other studies have also found deleterious effects of residence in enclaves on mortality; one study found that Hispanic residential segregation was associated with increased breast cancer mortality among women in Texas.<sup>27</sup>

Our study found that areas of higher Hispanic population density had higher rates of uninsured individuals and fewer primary care physicians. Healthcare facilities that Hispanics are able to access may also provide lower quality of care, partially explaining the higher mortality rates. Prior work has documented that care for elderly Hispanics is highly concentrated among certain hospitals, known as “Hispanic-serving

hospitals.”<sup>28–30</sup> These hospitals have lower-quality metrics and experience higher readmissions for acute myocardial infarctions and heart failure for both Hispanics and NHWs, even after adjustment for hospital and patient characteristics. It is likely that quality and resource disadvantages in these acute care hospitals impact CVD mortality and contribute to our findings. Similarly, in a study that looked at preventable hospitalizations among minority patients across 15 states, healthcare access, lower provider availability, and socioeconomic factors accounted for higher rates of preventable hospitalizations for Hispanics.<sup>31</sup>

We did not observe an association between Hispanic ethnic density and NHW mortality in unadjusted analyses. This is likely explained by the fact that we included only counties that had at least 20 Hispanic deaths, excluding ≈2428 counties. Counties where Hispanics live and die have less favorable socioeconomic factors. After adjusting for county-level characteristics, NHWs experienced lower CVD mortality rates in counties with a higher Hispanic proportion, although the effect size was small. A possible explanation for our findings is that areas of high Hispanic ethnic density are associated with improved outcomes for other ethnic groups living in the same area, thereby countering the effects of deleterious county-level characteristics. One study by Chetty and colleagues documented that life expectancy was positively correlated with local



**Figure 4.** Box-plot of fully adjusted cardiovascular mortality rate (per 100 000) for Hispanics and non-Hispanic whites by Hispanic proportion. The displayed results were adjusted for the following county characteristics: population size, proportion female, median household income, % under poverty line, % high school graduation, % some college, % unemployed, %black, % not proficient in English and % rural, % uninsured and primary care physician rate).

area fraction of immigrants ( $r=0.72$ ;  $P<0.001$ ).<sup>32</sup> That is, the higher the proportion of immigrants in a county, the higher the overall life expectancy of the entire county. Alternatively, county-level socioeconomic factors may account for more of the variation in socioeconomic-related CVD mortality among NHWs than among Hispanics. More granular socioeconomic measures (ie, for neighborhoods and individuals rather than counties) may be needed in future studies to further explore these associations across race/ethnic groups.

Our study has several important strengths, including a large, nationally representative sample of Hispanics and a focus on CVD mortality. Prior studies have been limited to Mexican Americans, whereas our analysis captures a more representative, heterogeneous group of Hispanics of all ages across the United States. Our analysis also adjusted for important county characteristics including demographic, socioeconomic, and healthcare factors, which may explain the relationship between Hispanic ethnic density and CVD mortality. Our findings should be interpreted in the context of several limitations. First, we used Hispanic proportion in US counties as a proxy for neighborhood composition. However, we also performed a sensitivity analysis using the isolation

index metric that showed qualitatively similar results (Table S2). Because of this methodological limitation, we were unable to control for more detailed, important neighborhood and individual-level characteristics such as the built environment, which may account for residual confounding. Our observed results may be due to unmeasured individual-level data, which may show different patterns than our ecological data. Our study is cross-sectional, which limits our ability to infer causality. Misclassification of race and ethnicity data on mortality records may have led to under- or overestimation of mortality rates. Finally, Hispanics are a very heterogeneous group and represent over 20 different national origins and degrees of acculturation.<sup>1</sup> Due to limited sample sizes, we are unable to account for subgroup or acculturation differences in mortality by Hispanic density.

Our findings suggest that residence in Hispanic ethnic enclaves is unlikely to explain the Hispanic paradox in CVD mortality. Furthermore, our work has important implications for public health interventions designed to reduce disparities among Hispanics. Such interventions should target areas of high-proportion Hispanic density and explore the adverse health consequences of residential segregation. Future studies examining the importance of ethnic density on CVD should



disaggregate Hispanics by subgroups and acculturation, as well as study these findings prospectively.

## Conclusion

In a large, national study of 10 years of mortality data, we found that Hispanic ethnic density is associated with increased CVD mortality for both Hispanics and NHWs. This finding persisted after adjusting for county-level characteristics among Hispanics. More work is needed to unpack the individual and neighborhood-level explanations for this observation.

## Sources of Funding

This work was supported by the National Institute on Minority Health and Health Disparities (R01MD007012) and the National Heart, Lung, and Blood Institute (F32HL132396).

## Disclosures

None.

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