Cardiovascular Mortality among Hispanics in Texas: A County Level Analysis

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BACKGROUND

Cardiovascular disease mortality is one of the leading causes of death in the United States and in many industrial nations. Noted disparities exist in CVD mortality by age, sex, race/ethnicity and socioeconomic status. Very little attention has been paid in the literature to the way in which residential segregation compounds these disparities. This study has examined the effects of residential segregation on CVD mortality using current data from the United States.

Cardiovascular disease- related to heart and blood vessels-, which consists of generally heart failure, coronary heart disease, heart attack, and stroke, is one of the leading causes of death in the world. More than 17 million people in the world died due to cardiovascular related diseases (CVDs) in 2008 (WHO, 2011). There is wide variation in the percentage of premature death due to CVD in developing and developed countries: 4 percent in developed countries and 42 percent in developing countries. (WHO, 2011)

Cardiovascular disease is also one of major causes of death in the USA. In USA, heart disease, one of the main components of cardiovascular disease, is one the leading causes of deaths in both gender, and all racial and ethnic groups. In 2008, diseases of heart claimed 616 thousand deaths. This was about 25 percent of total deaths in USA. Furthermore, deaths in men were higher than women in 2008 because more than half of the deaths were in men. Coronary heart disease is the most common type of heart disease. In 2008, 405,309 people died from coronary heart disease. From the racial /ethnic groups 20.7 percent of total deaths were in Hispanics i.e. the lowest after American Indians or Alaska Natives. From the burden of disease's perspective, it was estimated that coronary heart disease alone cost about $108.9 billion in 2010 (http://www.cdc.gov/heartdisease/facts.htm).

RATIONALE

A few studies have documented the effect of residential segregation on health outcomes including cardiovascular disease mortality and morbidity (Collins and Williams 1999; Sparks et al 2012; Congdon 2009; Fang et al 1998). Many of these studies have focused on black-white residential segregation and its effect on health outcomes including cardiovascular disease; studies examining the effect of residential segregation on cardiovascular mortality among Hispanics or Latino population are limited.

According to Hearst et al (2008), residential segregation is particularly important because it is associated with the negative access to resources such as structural, economic, social and individual resources. For example, the minorities are more likely to have "poor housing quality, environmental contaminants, lower educational and employment opportunities, access restriction to social services, limited access to healthy and fresh food options, high crime rates, low investment in infrastructure and poor access to medical services"(cited in Sparks et al.2012) because of their residential pattern. These could be potential mechanism to poor health outcomes including cardiovascular mortality. For cardiovascular mortality, not only individual behavioral risks are important, but also are contextual variables. These contextual variables could in the form of area SES and segregation (Yen and Syme 1999)

Swenson et al (2002) explained in their study, referring to other studies, Hispanics population have higher prevalence of cardiovascular risk factors than non-Hispanic Whites such as diabetes, obesity, high cholesterol (especially lipid abnormalities) and lower levels of physical activity; however, they have lower cardiovascular mortality than non-Hispanic Whites.

Therefore, the major objective of this study is to examine the effect of residential segregation on cardiovascular disease mortality in Texas after accounting for other socioeconomic variables at county level with or without accounting for spatial autocorrelation.

Neighborhood Effect on Health

Many of the health outcomes are affected not only from individual's health behavior, but also equally from where they live-neighborhood. Previous studies not only have documented the neighborhood effect on health, but also have documented the causal pathways. Previous studies have shown that the effect of social and economic features of neighborhood on health outcomes such as mortality (Irene H. Yen & Kaplan, 1999), cardiovascular disease risk factors and mortality (Sundquist et al., 1999), and many more. For instance, Ellen et al, 2003, in a comprehensive literature review, have enlisted the effect of neighborhood on health outcomes especially in health related behaviors such as smoking, drug and alcohol use, diet and nutrition, seatbelt use; mental health such as depression, anxiety, non- psychotic symptoms of distress; birth outcome such as low birth weights, infant mortality, other pregnancy complications; adult physical health such as self- rated health, functional limitation. Community socio economic status such as education, employment, and poverty also has effect on individual health outcomes. Yen and Syme (1999) in their content analysis enlisted four studies that have found association between area SES and cardiovascular disease (I. H. Yen & Syme, 1999).

From the theoretical perspective, the reasons behind the effect of neighborhood could be explained from two explanations: compositional and contextual. Compositional explanation explains that health outcomes are clustered in the neighborhood because of the similar health outcomes of the similar characteristics of residents in terms of their socio-economic characteristics or similar culture. These shared characteristics can explain in part the association of place and health. On the other hand, the contextual explanation assumes physical and environmental attributes of the area where people live affects affect the whole groups (Bernard et al., 2007).

Many studies have attempted to explore the causal pathways how neighborhood affect health outcomes. There are four possible mechanism through which neighborhood affect health: 1) neighborhood institution and resources 2) stresses in the physical environment 3) stresses in the social environment 4) neighborhood based network and norms (ELLEN et al 2003). Differential access to neighborhood institution and resources affects the health outcomes. Poor or deprived neighborhood may not have sufficient doctors or medical institution including medical technology. These neighborhood also lack public transport. It is also difficult for them to travel because of widespread crime in the neighborhood. Likewise, these neighborhood also have disadvantages in accessing neighborhood resources especially in health promoting behaviors and eating nutritious food.(ELLEN et al., 2003).

Second, stresses in the physical environment also affect health outcomes. These could be explained in the way that residents in poor and deprived neighborhood are more prone to expose to pollution and toxic sites, poor housing with lead paint, cockroaches infestation in the house, poorly maintained environment- crumbling staircase, decaying stairwells and dangerous playground, and low quality of municipal services. Lead paint has effect on neurological damage of children under six, cockroaches infestation has linked to childhood asthma etc.(ELLEN et al., 2003).Likewise, stresses in the social environment has been linked to exposure to crime and violence in the area. These exposures might increase stress. This may further cause other health related problems such as hypertension and stress related disorders. As a result, people might end up in smoking and other health risk behavior as a mechanism to reduce such stress. Last but not the least, while neighborhood based network and norms sometimes beneficial to sharing information seeking medical help about doctors and medical institutions, it has some kind of negative influence too. For instance, smoking and eating less healthy food may be acceptable in the community (ELLEN et al., 2003).

Residential Segregation and Cardiovascular Mortality

Residential segregation has also believed to have effect on cardiovascular disease and mortality. Sweson et al (2002) have found that residential segregation is linked to cardiovascular disease and mortality (Swenson, Trepka et al. 2002).Fang, et al. (1998), analyzing the New York City mortality records for the seven-year period from 1988 to 1994 and census 1990 data, found that the degree of segregation was negatively and independently associated with all cause and coronary heart disease mortality especially for people of 65 and over. They found that whites living in predominantly in white areas with higher socioeconomic status had lower mortality rates than whites living in predominantly black areas.

Surprisingly, some of the studies also found that residential segregation has protective effect too; however, this finding was from the studies done in New York only. Fang, et al. (1998), in their study found that found that elderly blacks living in the black areas had lower mortality including cardiovascular disease mortality (Fang, Madhavan et al. 1998). Likewise in other study in New York by also found Latinos living in predominantly in Latinos area had lower mortality than Latinos living in Black areas.(Inagami, Borrell et al. 2006)

Neighborhood SES and Cardiovascular mortality

Community socio economic status such as education, employment, and poverty also has effect on individual health outcomes. Studies have found association between area socioeconomic status and all-cause mortality including cardiovascular disease. Yen and Syme (1999) in their content analysis found that four studies have shown association between area SES and cardiovascular disease.

RESEARCH QUESTIONS

Following are the research questions of this study:

1) What is the effect of residential segregation on cardiovascular mortality among Hispanics in counties of Texas accounting for area level SES such as poverty, education, and unemployment rate of counties?

2) What would be its effects after controlling for spatial effect?

HYPOTHESIS

1) Residential segregation has positive effect on cardiovascular mortality at county level.
2) Area level SES such as poverty, unemployment rate have positive and education has negative effect on cardiovascular mortality.

DATA AND METHODS

Data sources

This study uses data drawn from two sources. Mortality data were taken from the vital statistics records for the period of 2005-2009 for each of the counties in Texas at the census tract level. Population data were taken from the 5-year estimates of ACS from the census Bureau.ACS 5-year (2005-2009) data was selected simply because of the mortality data was also from 2005-2009.

Outcome Variable

The outcome variable for this study was the number of deaths due to cardiovascular disease in each of the counties in Texas. The analysis of this study was limited to only those people of age above 34 years of age who died due to cardiovascular disease. The types of cardiovascular diseases included in the analysis according to its International classification of Disease (ICD) are given in table 1.In order to facilitate in comparison; age, sex, and Hispanic and non-Hispanic groups were taken to standardize deaths. Moreover, standardized mortality ratio (SMR) was also calculated.

Table 1 Cardiovascular disease type and associated ICD-10 codes from 113 causes of deaths

Codes	Description
49	Acute rheumatic fever and chronic rheumatic heart diseases
50	Hypertensive heart disease
51	Hypertensive heart and renal disease Ischemic heart diseases
52	Acute myocardinal infaction
53	Other acute ischemic heart diseases
54	Atherosclerotic cardiovascular disease, so described
55	All other forms of chronic ischemic heart disease
56	Acute and sub acute endocarditis
57	Diseases of pericardium and acute myocarditis
58	Heart failure
59	All other forms of heart disease

Source: CDC (http://www.cdc.gov/nchs/data/dvs/im9_2002.pdf.pdf)

Calculation for SMR

Standardized mortality ratio was calculated from internal standardization method, by adjusting age (25-64, 65-85 and 85+), sex (male and female), and Hispanics and non-Hispanics. While doing this we assume that each county experience the mortality schedule as of Texas (Sparks et al. 2012). The expected deaths were calculated from multiplying the ASDR for Texas - calculated from the internalization of deaths records- and the population of each counties in each age, sex, and Hispanic and non-Hispanic groups. The observed deaths and expected deaths in each age, sex and Hispanic and non-Hispanic groups were aggregated up at the county level. The SMR was calculated by dividing the observed and expected deaths at the county level.

Independent variables

Independent variables for this analysis were taken from ACS 5- year estimates at county level. Data were downloaded from official website of census Bureau.

a) Residential Segregation

According to Massey and Denton (1988), there are five dimensions of residential segregation measures such as evenness, exposure, concentration, centralization, and cluttering. However, in this analysis only first two out of five measures were used: evenness from index of dissimilarity and exposure from index of interaction.

i) Index of dissimilarity

The index of dissimilarity measures the evenness of residential segregation. This is calculated as:

$$D = \frac{1}{2}\sum_{i}^{n} \left| \frac{xi}{X} - \frac{yi}{Y} \right|$$

Where xi is the population of Hispanics in county I;

Yi is the population of Non-Hispanics in county i

X is the total population of Hispanics in Texas

Y is total population of Non-Hispanics in Texas

The value of index of dissimilarity falls between 0 to 1.Index of dissimilarity with 0 value suggests that the population are more similar or evenly distributed in the region whereas 1 value suggests that the population is more heterogeneous or unevenly distributed (Collins and Williams 1999; Sparks et al 2012).

ii) Index of Interaction

This measures the exposure of one group to another. This refers to the possibility of interaction between residents of different races within a county. This can be calculated by the following formula:

$$I = \sum_{i}^{n} \frac{xi}{X} * \frac{yi}{ti}$$

Where xi is the population of Hispanic in county i

yi is the population of Non-Hispanics in county i

ti is total population of county i

X is total population of Texas

The value of interaction Index also falls between 0 and 1.Interaction Index with 0 value means that there is no interaction between groups whereas its value 1 means higher interaction or perfect interaction. This represents the probability of randomly selected Hispanics (in our case) interacts with Non-Hispanic whites in a county (Collins and Williams 1999; Sparks et al 2012).

b) Other predictors

Three indicators were taken from ACS 5- year estimates each representing material deprivation, employment or occupational opportunity and education at county level. These three indicators are as follows: proportion of families under poverty, proportion of unemployment rate , proportion of population above 25 years who has bachelor degree or more.

Statistical Methods

Since the dependent variable was age adjusted observed deaths of Hispanics due to cardiovascular disease, we fitted the quasi-Poisson model because in the model building process, we found a lot of improvements in Quasi-Poisson model as compared to Poisson and negative binomial models- these models were found over- dispersed with parameter value more than 1.

In quasi-Poisson model, xi is distributed as Poisson with mean occurrence of event denoted by θ i. e

$$xi \sim P(ei\ \theta_i) * \lambda$$

where x_i is the number of observed deaths in each county, e_i is the expected death in each county and log of θ_i is the is the linear combination of covariates: $\ln \theta = X'\beta$ (Sparks et al 2012) and λ is the over dispersion parameter. The Quasi-Poisson will exactly turned to poison if the dispersion parameter is equal to one.

In the model, we assume that the number of deaths due to cardiovascular disease in each of i counties is a function of the expected number of deaths and other county specific covariates. The expected number of deaths was calculated as described earlier.

RESULTS

Table 2 below shows the total number of cardiovascular deaths in counties of Texas in 2005 to 2009.The total number of deaths from 2005 to 2009 in the counties of Texas was 176364.Of this, men’s mortality and women’s mortality due to cardiovascular disease were respectively 51 percent and 49 percent. White comprised of about 71 percent of total deaths followed by Hispanic. About 45 percent of deaths were in the 65 to 84 age group.

Table 2 Total number of deaths due to cardiovascular disease 2005-2009,Texas

	Deaths	Proportion
Sex		
Male	90499	0.513
Female	85865	0.487
Race		
white	124385	0.705
Black	20882	0.118
Hispanic	27878	0.158
Others	3219	0.018
Age group		
35-64	39493	0.224
65-84	78636	0.446
85+	58235	0.330
	176364	

Table 3 shows the descriptive statistics of average number of deaths in 5-year period, standardized mortality ratio, and spatial autocorrelation indicator-Global Moran’s I of Hispanic as well as non-Hispanics. The 5- year average of deaths due to cardiovascular disease was 21.95 for Hispanic and 116 for non-Hispanic population with standard deviation 89 and 325.The global Moran’s I was significant, significant at p=0.001 on 999 Monte Carlo re-samples -like Sparks et al (2012) did in their paper. The mean of SMR of Hispanic and non-Hispanics were respectively 0.8 and 0.96 which means that the overall observed deaths are still lower than the expected deaths. The variability in SMR among Hispanics was higher than non-Hispanics.

Table 3 Descriptive Statistics of Cardiovascular Deaths and SMR with Moran'I

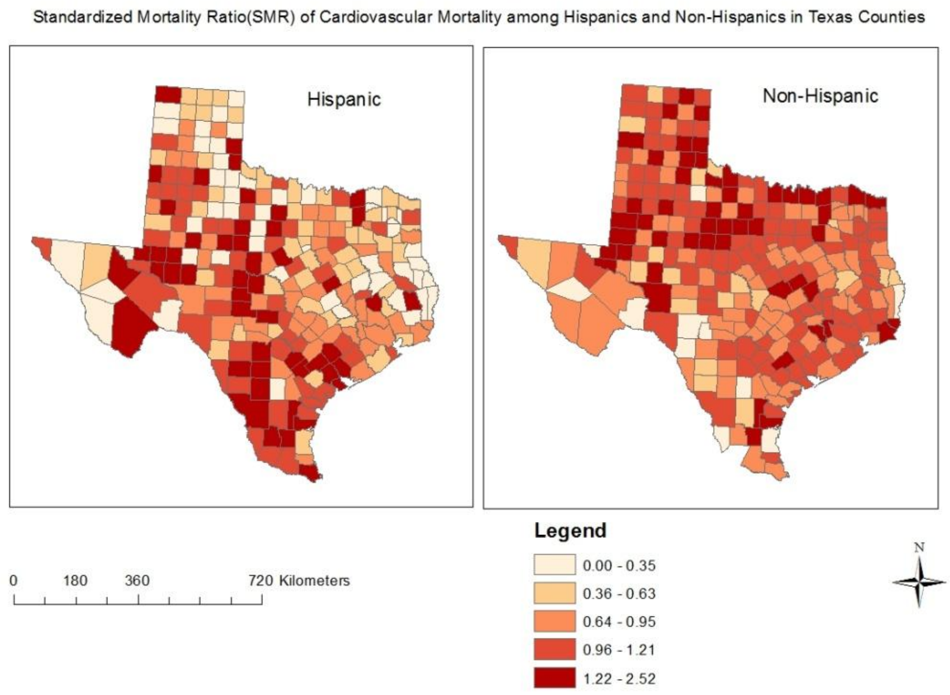
Variables	Hispanic			Non-Hispanic		
	Mean	Std	Moran's I	Mean	Std	Moran's I
Deaths	21.95	89	0.08*	116	325	0.19***
Standardized mortality ratio(SMR)	0.8	0.51	0.22***	0.96	0.33	0.089**

Table 4 shows the descriptive statistics of predictors: mean standard deviation and global Moran's I. The mean of dissimilarity index and interaction index were 0.0015 and 0.0005 respectively. The index of dissimilarity was very low which suggests that the population of Hispanic and White in Texas counties were evenly distributed. Likewise, mean of interaction was also low which also suggests that the possibility of interacting with White and Hispanic group was also higher. The positive values of Moran' I suggests that these values are dependent with the average value of the neighboring counties. Likewise, mean of percent of families under poverty threshold was 13.6 percent. The Moran'I value for this variable was 0.36.Likewise, unemployment rate was 6 percent with Moran' I value of 0.24.In the similar manner, percentage of population 25 years and over with Bachelor and higher degree was 17 percent with positive Moran's I value of 0.27.

Table 4 Descriptive Statistics of predictors

	Mean	Std.	Moran's I
Dissimilarity Hispanic-Non-Hispanics	1.50E-03	0.004	0.23***
Interaction of Hispanic – Non-Hispanics	5.27E-04	0.002	0.15
Percent of families under poverty Threshold	0.136	0.06	0.36***
Unemployment rate	0.06	0.02	0.24***
Percentage of population 25+ with Bachelor and higher degree	0.17	0.07	0.27***

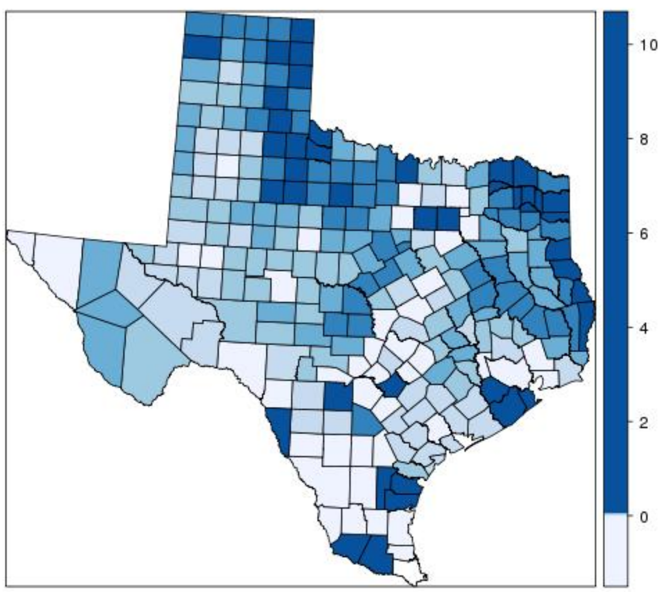
The following map shows the standardized mortality ratio (SMR) of Hispanic and Non-Hispanic population in Texas counties which were made by using Arc GIS. The map shows that the SMR calculated for Hispanics at county level were clustered with high values in counties of south Texas whereas for Non-Hispanic, higher values of SMR were found in northern counties of Texas.



Multivaiate Analysis

Table 5 shows the results of quasi -Poisson regression models with or without spatial filtering. In the first model, quasi-Poisson model without spatial filtering was used. The model found that measures of residential segregation were significant in explaining its effect on the cardiovascular deaths. This shows that one standard deviation change in standardized dissimilarity Index increases the cardiovascular mortality by 4 percent. However, one standard deviation change in standardized interaction index score lowers the cardiovascular mortality rate by almost 3 percent. Likewise, one standard deviation change in unemployment rate in counties lowers the cardiovascular disease mortality of Hispanics by 12 percent. Likewise, one standard deviation change in standardized proportion of population 25 years and over with bachelor and higher degree lowers the cardiovascular disease mortality population by 11 percent.

The result shows that most of the predictors are significant in explaining the effect on cardiovascular disease mortality except proportion of families below poverty. The estimates might be affected by the average of these values in each of the neighboring counties. The global Moran's I test for quasi-Poisson model without spatial filtering was found to be 0.32 and significant. This tells us that the cardiovascular deaths of each county are dependent on average of cardiovascular deaths of neighboring counties. The following map of local Moran'I also supports this spatial dependence pattern. Higher values of local Moran'I tells us spatial clustering of autocorrelation.



So in order to find the true effect of these predictors, we controlled for spatial dependence by using quasi-Poisson model with spatial filtering. Table 5 shows the result of the model.

In this model too, each of the predictors were significant except poverty variable. The effect of each of the variable did not change that much except education variable. One standard deviation change in standardized proportion of population 25 years and over with bachelor and higher degree lowers the cardiovascular disease mortality by 64 percent. This is drastic change in effect.

From ANOVA test of these two models, quasi-Poisson model with spatial filtering model was found to be better (F statistics- 13.06 with p value- 0.00036)

Table 5 Summary of quasi-Poisson models with or without spatial filtering

Predictors	Without spatial filtering		With spatial Filtering	
	B	Exp(B)	B	Exp (B)
(Intercept)	0.079***	1.08	0.075**	1.075
Standardized dissimilarity Index- Hispanic-White	0.04***	1.04	0.037***	1.04
Standardized Interaction Index – Hispanic-White	-0.03***	0.97	-0.041***	0.956
Standardized proportion of families under poverty threshold	0.004	1.00	0.031	1.03
Standardized unemployment rate	-0.119***	0.88	-0.106**	0.899
Standardized proportion of population 25 years and over with bachelor and higher degree	-0.113***	0.89	-0.099***	0.336
Spatial filtering	-	-	-1.091***	1

*** significant at 0.0001 ** significant at 0.001 * significant at 0.05

<u>For without spatial Filtering</u>
Null deviance: 479.50 on 253 degrees of freedom
Residual deviance: 319.32 on 248 degrees of freedom

<u>For spatial Filtering</u>
Null deviance: 479.50 on 253 degrees of freedom
Residual deviance: 305.04 on 247 degrees of freedom

DISCUSSION

For the outcome variable such as count and rate, Poisson regression is generally used .However, for the over dispersed- variance is higher than mean- we use negative binomial or quasi- Poisson models are used. In this study also, quasi -Poisson model was used to examine the effect of residential segregation and other county level variables with or without accounting for spatial autocorrelation or dependence. This study found that the effect of residential segregation was mixed. The dissimilarity index has positive effect whereas interaction has negative effect on cardiovascular mortality. This finding was consistent in two models. Likewise, other independent variables were also found having significant effect on cardiovascular mortality of Hispanic group at county level except poverty variables. The proportion of families below poverty threshold did not reveal any effect on the county level cardiovascular mortality. The most plausible reason behind this could be that poverty might be equally distributed to Hispanic groups in each county. However, surprisingly, unemployment rate in the county have negative effect on cardiovascular disease mortality. Generally unemployment rate have positive effect on many of the health outcomes, more exploratory research is necessary in this regard. In the same manner, education was found having a big effect on cardiovascular mortality in each of the county. The proportion of population with bachelor level or higher education has negative effect on the county level cardiovascular mortality. This is possible because higher education is associated with good job and good job can work as anti-stressor.

CONCLUSION

The analysis supports that residential segregation such as indices of dissimilarity and interaction are associated with age adjusted cardiovascular mortality among Hispanic or Latino at county level. The dissimilarity index increases the likelihood of cardiovascular disease mortality whereas interaction index lowers the cardiovascular mortality. This study also found that unemployment rate and education also have negative effect on cardiovascular mortality rate: education has particularly tremendous effect on cardiovascular deaths.

LIMITATION

There is couple of limitations of this study. This study uses only segregation measures by calculating dissimilarity index and interaction index. However, other measures of segregation could also affect the cardiovascular mortality rate. This study used only three major indicators of neighborhood and did not use community level risk factors for cardiovascular morbidity and mortality for instance proportion of population who smoke, proportion of population that was obese, hypertension etc. Future research could focus on these variables to explore the effect of these variables for cardiovascular mortality.

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