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Using community based participatory research to develop geospatial models toward improving community health for disadvantaged Hispanic populations in Charlotte, NC

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Abstract

Hispanic immigrant communities across the U.S. experience persistent health disparities and barriers to primary care. We examined whether community-based participatory research (CBPR) and geospatial modeling could systematically and reproducibly pinpoint neighborhoods in Charlotte, North Carolina with large proportions of Hispanic immigrants who were at-risk for poor health outcomes and health disparities. Using a CBPR framework, we identified 21 social determinants of health measures and developed a geospatial model from a subset of those measures to identify neighborhoods with large proportions of Hispanic immigrant populations at risk for poor health outcomes. The geospatial model included four measures—poverty, English ability, acculturation and violent crime—which comprised our Hispanic Health Risk Index (HHRI). We developed a Primary Care Barrier Index (PCBI) to determine 1) how well the HHRI correlated with a statistically derived composite measure incorporating all 21 measures identified through the CBPR process as being associated with access to primary care; 2) whether the HHRI predicted primary care access as well as the statistically-derived composite measure in a statistical model; and 3) whether the HHRI identified similar neighborhoods as the statistically-derived composite measure. We collapsed 17 of the 21 social determinants using principal components analysis to develop the PCBI. We determined the correlation of each index with inappropriate emergency department (ED) visits, a proxy for primary care access, using a generalized estimating

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equation. Results from logistic regression models showed positive associations of both the HHRI and the PCBI with the use of the ED for primary care treatable conditions. Enhanced by the knowledge of the local community, the CBPR process with geospatial modeling can guide the multi-tiered validation of social determinants of health and identify neighborhoods that are at-risk for poor health outcomes and health disparities.

Keywords

Disadvantaged populations; Primary care; Participatory research

Introduction

Health disparities experienced by the U.S. Hispanic population are becoming more prominent, due in part to a lack of access to primary medical care. Although this group bears a disproportionate burden of diseases and conditions such as hypertension, diabetes, and HIV/AIDS, they are the least likely to access preventative health services. For example, the incidence of diabetes among Hispanic adults exceeds rates for non-Hispanic whites by 43% (Beckles, Zhu, Moonesinghe, & Centers for Disease Control and Prevention, 2011). Between 2004 and 2007, Hispanics experienced 110,000 more preventable hospitalizations than non-Hispanic Whites (Moy, Barrett, Ho, & Centers for Disease Control and Prevention, 2011). Hispanics are also less likely to receive preventable services like flu vaccinations and more likely to live in unhealthy environments (Centers for Disease Control and Prevention, 2013). These disparities in health and access to care are more pronounced among recently arrived Hispanic immigrants who have yet to acculturate to their new surroundings (Ransford, Carrillo, & Rivera, 2010).

The social and spatial contexts in which Hispanic immigrants live play a major role in these observed disparities (Berk & Schur, 2001; Documet & Sharma, 2004; Leduc & Proulx, 2004; Vines & Godley, 2004). Lack of medical insurance, low socioeconomic status, limited English proficiency, inadequate transportation, and mistrust of the medical system are some of the factors that impede access to primary care and lead to the inappropriate use of emergency departments (Vines & Godley, 2004). Lack of English language skills makes navigation of the complex U.S. healthcare system a challenge, compromises relationships with providers, and impedes adherence to medical recommendations (DuBard & Gizlice, 2008). Recent arrivals also often lack robust social support networks that are important for maintaining good physical and mental health (Surkan, O'Donnell, Berkman, & Peterson, 2009). The low-income neighborhoods in which many new immigrants live present additional health hazards such as exposure to pollution and poor sanitation, and often fail to support healthy lifestyles (Rosenbaum, 2008). Moreover, undocumented immigrants who fear deportation may delay or avoid needed medical care (Berk & Schur, 2001).

Charlotte, North Carolina provides a model setting in which to identify new ways to mitigate barriers and improve health outcomes for disadvantaged Hispanic immigrants. The city and surrounding Mecklenburg County represent a prototypic twenty-first century immigrant gateway (Singer, Hardwick, & Bretell, 2008; Smith & Furuseth, 2003). Between 1990 and

2000, in-migration led to a 932% increase in the metro area's Hispanic population (Suro & Singer, 2002). By 2010, Hispanic residents constituted 13% of Charlotte's population. As a group, Charlotte's Hispanics are less educated and poorer than any other racial or ethnic group. About 27% of Charlotte's Hispanic population lives at or below the poverty level, and an estimated 58% of all Hispanic adults lack health insurance (United States Census Bureau, 2010). In 2008, 29% of North Carolina's Hispanic population had not experienced routine medical care because of cost, the highest share of any ethnic group in the state (North Carolina Office of Minority Health and Health Disparities, 2010).

The rapid and continuing influx of new Hispanic immigrants has challenged health care providers and facilities in Charlotte. Nonetheless, Charlotte has a unique opportunity to create constructive relationships between health care providers and the Hispanic immigrant community to proactively and positively impact community health, improve cultural understanding, and break down barriers between community members and health providers (Singer, 2004). Even more importantly, the lessons from Charlotte and Mecklenburg County offer useful guides for other twenty-first century immigrant gateways, places where conventional immigrant health care paradigms are not always applicable (Cisneros, 2008).

The community-based participatory research (CBPR) paradigm provides one promising approach to building relationships between health care providers and Hispanic immigrants and addressing health disparities (Dulin et al., 2012; Wallerstein & Duran, 2006). CBPR empowers community members and researchers to work as equal partners in identifying collaborative research topics of importance to the community and developing effective research plans and implementation strategies that combine and build upon the unique strengths of all (The Examining Community-Institutional Partnerships for Prevention Research Group, 2006). Although researchers recommend CBPR as a means of promoting community relationships and providing a framework for developing community interventions, only a handful of published studies demonstrate the effectiveness of CBPR in directly influencing health outcomes, indicating a clear need for additional research (Green & Hickner, 2006; Kinney, Aggarwal, Northridge, Janssen, & Shepard, 2000; Macaulay et al., 1998; Macaulay, Hanusaik, & Beauvais, 1991; Nevin & Gohel, 1996). Validating the outcomes produced by CBPR provide the evidence necessary for future projects to incorporate these methods (Kraemer Diaz, Spears Johnson, & Arcury, 2013; Leung, Yen, & Minkler, 2004; Minkler, 2004). These validation studies are particularly lacking on the topic of health equity in the non-English speaking population (Farrer, Marinetti, Cavaco, & Costongs, 2015).

As part of a multiyear project with the overall goal of improving the health of underserved Hispanic immigrants in Charlotte, we examined how CBPR methods and geospatial modeling can systematically and reproducibly identify neighborhoods at risk for poor health outcomes within our community. This paper includes four objectives. First, we describe the iterative process of identifying multiple social determinants of health and health disparities at the neighborhood level using CBPR methods. Second, we describe the development of the Hispanic Health Risk Index (HHRI), a geospatial model developed using CBPR methods. Third, we use the results of the HHRI to identify neighborhoods with large proportions of their Hispanic immigrant populations at risk for poor health outcomes. Fourth, we describe

the Primary Care Barrier Index (PCBI), a statistical model, developed to validate the results of the HHRI geospatial model.

Methods

CBPR Approach

As noted above, a CBPR framework grounded the research process. Researchers, physicians, community members, and organizations serving Hispanic immigrants actively and equally provided input at various stages of the research process. A Community Advisory Board (CAB) consisting of the research team and representatives from the local public school system, parks and recreation, city/county government, university departments, and Hispanic immigrant community organizations developed and reviewed the research concept. As the CAB for the Practice Based Research Network (PBRN) conducting this research, the CAB had been in place for three years prior to the beginning of the project and had experience providing critical input into all stages of the research process; and grounding and refining approaches operationalized by the research team. Key informant interviews and focus groups with healthcare providers and community members who had familiarity with the provision of healthcare for Hispanic/immigrant populations and/or with the neighborhoods at the core of the study, allowed the research team to gather additional community input.

The research team achieved methodological triangulation to validate the study by combining and comparing information from these qualitative processes with quantitative analyses of neighborhood data and hospitalization records.

Qualitative Data Collection

We used literature reviews, focus groups, CAB involvement, and key informant interviews to identify and confirm themes and concepts of social determinants of health. Data sources for the literature review included peer-reviewed articles, government reports, and grey literature. We also conducted eight focus groups and eight key informant interviews with Hispanic immigrant community members and health/social service providers during the Spring of 2011. We held three focus groups with members of the Hispanic immigrant community, three with health care providers, and two with a combination of providers and community members. We conducted key informant interviews with representatives from law enforcement, the justice system, the media, and social and mental health services. The CAB referred interview participants, who included a judge, police officer, narcotics detective, mental health provider, executive director of an advocacy organization, and representative from a children's health insurance program. We asked focus group and interview participants to identify the most influential social determinants impacting the health of the Charlotte Hispanic immigrant community either positively or negatively. We also asked participants to review and provide insight into the variables identified from the literature review. The research team recorded and transcribed all focus groups and interviews. Two members of the research team analyzed the transcriptions to identify social determinants of health themes, which the CAB also reviewed.

We identified a list of 80 social determinants of health for Charlotte's Hispanic immigrant population and refined the list so that only terms identified by at least two of the three methods (literature review, focus groups, and key informant interviews) remained. This triangulation narrowed the list to 30 health-related concepts (see Table 1). The research team and the CAB then worked collaboratively to identify which of these concepts we could measure and map at the census tract level using available data. The team identified 20 measurable and 10 immeasurable concepts. Table 2 displays 21 measures (one concept had two different measures) that represent the 20 concepts, the definition of each measure, and its associated data source. Table 2 also lists the 10 concepts with no available data.

Geospatial Model Development

We began our geospatial model development process by compiling a spatial distribution of the Hispanic population across city neighborhoods. We examined both census tract and neighborhood boundaries (utilizing Neighborhood Statistical Areas) for Mecklenburg County as of 2010. As shown in Figure 1, we produced maps using these two boundaries that revealed similar patterns of "neighborhoods" with high proportions of Hispanics among their resident populations. Each map identified at least 46 neighborhoods with more than 750 Hispanic residents. Census tract level data provide more complete measures of social determinants of health. Therefore, our final analysis applied census tract boundaries to delineate neighborhoods. While Mecklenburg County consisted of 233 census tracts, this study included only census tracts with data available to determine a value for social determinant measures for the Hispanic immigrant population.

Development of the geospatial model also involved the Multiple Attribute Primary Care Targeting Strategy (MAPCATS), illustrated in Figure 2. MAPCATS uses an analytic hierarchy process and multiple attribute assessment and evaluation to combine multiple variables/data sets into a composite geospatial model that the community verified (Dulin et al., 2010a, 2010b). We applied the MAPCATS methodology to the 21 social determinants of health measures identified through the CBPR process.

We obtained quantitative data for the 21 social determinants of health measures for the geospatial model from publicly available data and hospital billing records (Table 2). We obtained 2009 hospital billing data on healthcare utilization for Hispanic patients in Charlotte from Carolinas HealthCare System, the public hospital authority in Charlotte/Mecklenburg County and the largest provider of care to Medicaid recipients and the uninsured. Variables captured in the hospital billing data included International Classification of Disease, Ninth Revision Clinical Modification (ICD-9 CM) diagnosis codes, patient age, race, ethnicity, gender, insurance status, and patient address. We extracted emergency department visits by Hispanic patients residing in Mecklenburg County ($n=12,840$). We geocoded patient addresses and linked by census tract to data from the American Community Survey (United States Census Bureau, 2010).

The research team collected, analyzed, and mapped data for each of the 21 measures at the census tract level for Mecklenburg County. We distributed the social determinant maps to the CAB which further prioritized the mapped measures, narrowing the list from 21 to 10 using the MAPCATS process. Frequently identified variables in the literature review, focus groups,

and key informant interviews influenced a component of the prioritization process. The CAB and the research team assessed the final ten indicators to determine overlap and correlation between the variables using the MAPCATS model. The CAB sought to ensure that results could be easy to explain, understand, and illustrate in a reasonable amount of time for a public presentation. The CAB provided a final prioritization by narrowing down the list to the four most important variables based on the perceived health impact of each.

The prioritization by the CAB involved iterative negotiations related to variable selection. Some social determinants concepts were easier to quantify than others. Community participants found it easier to understand familiar measures. In some cases, immeasurable social determinants were dropped from the list because the data needed did not exist at the census tract geography. For example, qualitative interviews identified religion as a social determinant of health for this population. However, religious affiliation did not exist at the geographic level needed. When such data challenges arose, the research team and CAB explored alternative measures and identified proxy variables to represent concepts important to the community. For example, the violent crime rate using data from the Charlotte-Mecklenburg Police Department approximated neighborhood safety. The geospatial model originally included education based on the percentage of adults with a high school education. However, the community did not identify this variable as being a social determinant. Therefore, English ability better represented the community of interest and the findings derived from the interviews and focus groups. The final list of four measures represented unique social determinants considered important based on best evidence as well as community insight. The list included measures for acculturation, English ability, poverty, and violent crime.

Identification of the Neighborhoods at Risk for Poor Health Outcomes

The final geospatial model developed through the CBPR process consisted of four measures combined into a single, evenly weighted index. Data used to define the four measures were as follows: poverty - Hispanic/Latino families below the poverty line; acculturation - Latin American-born population who entered U.S. in 2000 or later and are not U.S. Citizens; English ability - Hispanic/Latino population (5 years and older) speaking only Spanish at home and not proficient in English; and violent crime - violent crime offenses per capita.

We standardized the four measures using *z* scores and combined them into a single, evenly weighted index, which we termed the Hispanic Health Risk Index (HHRI). We presented this simplified model, derived from triangulated methodologies and successive rounds of CAB and research team review, in a public forum. Figure 3 shows the spatial distribution of each measure individually. N/A in the maps indicates areas with insufficient Hispanic population to determine a value.

Validation of the Hispanic Health Risk Index

Access to primary care depends on several socioeconomic and geographical facts that differ across different population cohorts. The HHRI incorporated four factors into a simplified geospatial model with the goal of identifying neighborhoods with reduced access to primary care. Following the development of the HHRI model, we sought to evaluate: 1) how well the

HHRI correlated with a statistically derived composite measure incorporating all 21 measures identified through the CBPR process as factors associated with access to primary care; 2) whether the HHRI predicted primary care access as well as the statistically-derived composite measure in a statistical model; and 3) whether the HHRI identified similar neighborhoods as the statistically-derived composite measure.

We measured access to primary care by emergency department (ED) visits for conditions normally treated in a primary care setting, otherwise known as ambulatory care sensitive (ACS) conditions, or inappropriate ED visits. Previous research suggests that hospitalizations and ED visits for ACS conditions are markers of poor access to primary care services (Falik, Needleman, Wells, & Korb, 2001; Laditka, Laditka, & Probst, 2005). We applied the New York University algorithm (Billings, Parikh, & Mijanovich, 2000) to identify ACS conditions from ED visits, which computes the probability (range 0 to 1) that each emergency department visit was due to an ACS condition. We categorized visits with a probability greater than 0.5 as ACS (McWilliams, Tapp, Barker, & Dulin, 2011). We created a binary variable (1=yes; 0=no) that indicated whether a patient had ever used the ED for an ACS condition over the one year study period in 2009. By validating the geospatial HHRI model identified by the CBPR approach, we sought to assess how well the prioritization process performed to identify areas with lack of access to primary care relative to the full list of variables identified via literature review, interviews, and focus groups. In addition, the process gave communities the option to use the HHRI model even if they lacked the expertise to conduct similar statistical validation.

Statistical Analysis to Develop the Primary Care Barrier Index

We used principal components analysis to create a composite measure to represent the 21 measures identified through the CBPR process as factors associated with access to primary care. This method creates new uncorrelated variables that explain the variation between the original list of highly correlated variables. While a principal components analysis produces as many new variables as original variables, consistent with prior research, we retained only the first principal component, which accounted for the most variation among the measures (Messer et al., 2006). We excluded four neighborhood variables (access to grocery stores, multi-generational families, presence of children, and unemployment rate), with a correlation of less than 0.25 with the first principal component (Messer et al., 2006). We used the 17 remaining measures to construct a primary care barrier index (PCBI) that had an eigenvalue of 6.24 and accounted for 37% of the total variation (6.24/17) in these measures (Table 3).

We used Pearson correlation statistics to assess the linear relationship between the PCBI and the HHRI. We used logistic generalized estimating equations (GEE) to examine the association between ED visits for ACS conditions and the HHRI, while adjusting for clustering between patients living in the same geographic area. We used similar models to assess the association between the PCBI and ED visits for ACS conditions. We adjusted the models for patient age and gender. We reported model results as odds ratios and 95% confidence intervals (CI) and used the quasi-likelihood under the independence model

criterion (QICu) to compare model fit (Pan, 2001). We conducted all statistical analyses using SAS version 9.4 (SAS Institute, Cary, NC).

Results

To meet our first objective, we identified measures of social determinants that contributed to health outcomes and disparities at the neighborhood level for Charlotte's Hispanic immigrant population (see Tables 1 and 2). In our second and third objectives, we developed the HHRI using CBPR and the MAPCATS process to create an equally weighted index based on four measures (Table 2). We used the HHRI to identify neighborhoods at risk for health care disparities related to access to primary care and to create maps to assist in future intervention development and deployment. Figure 4 displays the resulting combination of the four measures into the HHRI and the spatial distribution by census tract of values across Mecklenburg County. The HHRI ranged from -1.4 (indicating low risk for poor healthcare utilization) to 4.0 (indicating high risk for poor healthcare utilization). Tracts with the highest index values appeared in areas to the southwest, northwest, northeast, and east of downtown, while tracts found in south Charlotte and the northern and southern suburbs displayed the lowest values.

The PCBI, a composite measure incorporating 17 variables associated with primary care access, ranged from -2.45 (indicating few barriers) to 2.61 (indicating many barriers). Tracts with the highest index values appeared in southwest, northeast, and east Charlotte, while tracts in south Charlotte and the northern and southern suburbs displayed the lowest values (Figure 4). The maps showing the distribution of the HHRI values and the PCBI values across Mecklenburg County displayed highly similar patterns. Both highlighted tracts in the southwest, northeast, and east Charlotte had higher values, while the lowest values appeared in south Charlotte and the northern and southern suburbs. One exception was the prominence of several tracts in west Charlotte in the map of the HHRI, which we did not observe with the PCBI. We found a correlation of 0.84 ($p < 0.001$) between the two indices. Three of the four measures in the HHRI, namely acculturation, English ability, and violent crime, correlated highly with the PCBI. The final measure, poverty, had a slightly lower correlation with the PCBI ($r = 0.40$).

Results from logistic regression models showed positive associations of both the HHRI and the PCBI with use of the ED for primary care treatable conditions (Table 4). Each one-point increase in the HHRI corresponded to 10.6% higher odds of ED use for primary care treatable conditions, while each one-point increase in the PCBI corresponded to 8.3% higher odds of ED use for primary care treatable conditions. Comparisons of the models using the QICu suggested a better model fit using the PCBI. However, overlapping confidence intervals indicated comparable associations with the measure of access to primary care.

For the fourth objective, we validated the HHRI model with the PCBI and found that the HHRI indicators correlated highly with indicators of access to primary care. The convergence of the CBPR-developed HHRI and the PCBI derived through principal components analysis further validated the use of the CBPR process and the utility of the MAPCATS model for targeting health interventions.

Discussion

The results of this study suggest there are key issues in access to primary care for Charlotte's Hispanic immigrant community such as poverty, acculturation, English ability, and violent crime, which reflect findings in other studies across the country. A study on Hispanics in Southwestern Pennsylvania found a significant relationship between time in the U.S. and having a regular source of care (Documet & Sharma, 2004). DuBard and Gizlice (2008) found that not speaking English has a negative impact on Hispanic health outcomes. Three of these measures, namely acculturation, English ability, and violent crime, also highly correlated with our PCBI. The final measure, poverty, had a slightly lower correlation. However, previous studies have shown that poverty is an important risk factor for primary care access (Butler, Petterson, Phillips, & Bazemore, 2013).

Use of CBPR provides several advantages over geospatial or statistical modeling alone. Our early engagement of community members in prioritizing issues of interest reduced hurdles involved with designing and implementing the health interventions that flowed from this work. The research team received feedback from the public around the geospatial model and our process for its development. Without the collaboration between the CAB and the research team, for example, the community may have viewed with suspicion our model identifying the neighborhoods at risk for poor health outcomes and ideas for interventions may not have been as forthcoming or as grounded in real world experience. The iterative CBPR process built a sense of ownership and investment among those involved, resulting in greater confidence in the results. CAB members participated in the forum to identify interventions and could speak to the process with confidence. Similarly, in a study by Hill, Chau, Luebbering, Kolivras, and Zoellner (2012), geospatial models developed using CBPR proved useful in informing the process for addressing obesity in the study's community. Other studies indicated that community members who understand the process for selecting target neighborhoods are also more likely to advocate for fairness and equity and help gauge the readiness and feasibility of specific neighborhoods for specific intervention programs (Caley, Shiode, & Shelton, 2008; Cromley et al., 2011).

The geographically-based findings of the HHRI align with earlier research by Smith and Furuseth (2003) that examined Hispanic immigration settlement in Charlotte. This research showed that Hispanic immigrants arriving in the U.S. post 1990 targeted suburban areas built between the 1950s and 1970s for residential settlement. As destination neighborhoods for successive waves of immigrants, these aging suburban areas have the highest concentration of newcomers with higher risk of poor health outcomes. In contrast, immigrants with lower risks settled in new suburban settings with lower overall concentrations of Hispanic immigrants.

Our findings—that a relatively simple index comprised of a handful of key community-identified measures can identify areas at risk for health disparities and poor health outcomes with a level of success that is similar to using a complex statistical model with a more comprehensive set of variables—offer a promising avenue for other communities likely to do similar work but might not have the expertise or resources to build complex statistical models.

Therefore, we propose that other communities that have limited expertise or resources to build statistical models and extract needed data from their hospital systems use the HHRI. Communities can readily apply the low cost HHRI model using standard data sources to focus community-based interventions aimed at improving health services utilization where they will have the most potential impact.

Our study also suggests that providing an opportunity to allow the community to participate in the research process by identifying variables, selecting those to be included in the model, and approving the final geospatial model, provides a similar outcome to a process that is purely driven from evaluations using “research only” derived variables. Our study shows that the community-derived variables correspond to those identified by other studies. In this way, the weight of community input is equal to input from scholarly and more academic sources. By combining the variables into the HHRI, communities across the country could replicate this process if they agreed upon the same measures to include in the geospatial model. Although the CBPR approach did require more participation from non-research partners and took more time, the process provided further in-depth information about neighborhoods with large proportions of Hispanic immigrants who are at risk for poor health outcomes and health disparities, and personal knowledge about the communities that statistics such as traditional concentrations of Hispanic populations alone could not illustrate.

Additional time allotted for CAB input gave them the opportunity to negotiate their differences concerning variable selection. The research team proposed variables that aligned more with the given research literature, whereas the community provided examples of variables more representative of their personal experience in the community. The example cited above regarding education and English ability variables provides an illustration of the push and pull between researchers and community members. Such conversations are important to ensure that outcomes reflect respect for diverse opinions and that the results truly represent what the community identifies with, not just what the research literature dictates. With that said, what the community identifies should also represent what sound research is likely to replicate.

This study has several limitations. Lack of available data at the census tract geographical level required the exclusion of some variables prioritized by the community. One hospital system provided the study data; therefore, our analysis did not capture ED visits at other locations. However, our data included 70% of the emergency departments located in areas with large Hispanic populations. We did not include access to a provider as a variable in our models. The Hispanic immigrant population under study included a large segment of undocumented immigrants, which made access to a provider difficult to measure accurately. For this population, access to a provider from a geographical perspective does not equal access to provider from an income/documentation status perspective. The use of census tracts as the “neighborhood” unit often masks true neighborhood boundaries. However, similar research by Bell et al. indicates that patterns of primary care access at the census tract level are not very different from those using neighborhood boundaries (Bell, Wilson, Bissonnette, & Shah, 2013). Although the HHRI is an appropriate tool to target community-based interventions, we did not design it to measure changes in utilization that occurred because of deployed interventions. Therefore, communities that need to evaluate

interventions for access should either use qualitative data or determine other approaches for measuring impact. Finally, we did not test the likelihood of the intervention's success as measured by increased levels of buy-in from affected constituencies. Further research needs to demonstrate the degree to which an initial CBPR process can improve interventions directed towards the community health of disadvantaged Hispanic populations.

Conclusion

Hispanic immigrant communities across the U.S. experience marked barriers to primary care access and disparities in health outcomes. We examined whether CBPR principles and geospatial modeling could systematically and reproducibly identify high-risk neighborhoods within the Charlotte Hispanic immigrant community. Our findings informed the selection of neighborhoods in which to develop and implement interventions to improve the utilization of preventative services for Hispanic immigrant community members living within the high-risk neighborhoods. Furthermore, our study complements the broader immigration research literature that reports significant shifts in the twenty-first century immigrant settlement in aging suburban settings and associated challenges surrounding effective public service deployment for foreign-born newcomers. This study also introduces a novel approach that, through CBPR, triangulates quantitative and qualitative methodologies, allowing the real-world experience of the community to inform the development, assessment, and application of a geospatial and statistical model that other cities can adapt to identify areas of need and to target interventions.

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Hispanic Population Number by Census Tract

Hispanic Population Number by Neighborhood Statistical Area

Fig. 1.
Mecklenburg County, NC, census tract and neighborhood statistical area boundaries.

Fig. 2. Overview of process used to select measures in the development of the geospatial model included in the Multiple Attribute Primary Care Targeting Strategy (MAPCATS).

Fig. 3.
 Maps of Mecklenburg County, NC, showing the geographic distribution of Poverty, Acculturation, English ability, and Violent crime.

Fig. 4.
Spatial Distribution of Hispanic Health Risk Index and Primary Care Barrier Index in Mecklenburg County, NC.

Table 1

Top 30 Social Determinants of Health identified in the first stage of developing the geospatial model.

Social Determinants of Health Concepts	Source		
	Literature Review	Focus Groups	Key Informant Interviews
Access to grocery stores	X	X	
Access to parks/recreation centers		X	X
Access to public transportation	X	X	
Access to technology		X	X
Acculturation	X	X	X
Deportation rates	X	X	
Domestic violence		X	X
Education level	X	X	X
English ability	X	X	X
Family structure	X	X	X
Gang membership		X	X
Hispanic population (Country of origin)	X	X	
Homeownership	X	X	
Hospitalization rate	X	X	
Household income	X	X	
Legal status	X	X	X
Mental health (Depression)	X	X	X
Multi-generational families	X	X	X
Poverty (Economic status)	X	X	
Presence of children	X	X	
Previous residence	X		X
Quality of life - real and perceived		X	X
Religion	X	X	X
Safety net clinic use	X	X	X
Social support network	X	X	X
Time of arrival	X	X	
Transportation	X	X	X
Type of employment/occupation	X	X	X
Unemployment rate	X	X	
Violent crime (Safety)	X	X	

Table 2

Social determinant concepts associated with the health of Hispanic immigrants.

Social Determinants of Health Measures	Measure Definition	Data Source
Access to grocery stores	Percent of households within ¼ mile of a chain grocery store	Grocery chain websites
Access to public transportation	Percent of households within ¼ mile of a bus stop or ½ mile of a light rail stop	Charlotte Area Transit System
Acculturation	Percent of total population that was born in Latin America, entered U.S. in 2000 or later, and is not a U.S. citizen	2005–2009 American Community Survey 5-year estimates
Education level	Percent of Hispanic/Latino population (25 and older) with less than a high school diploma	2005–2009 American Community Survey 5-year estimates
English ability	Percent of Hispanic/Latino population (5 and older) that do not speak English well or at all	2005–2009 American Community Survey 5-year estimates
Family structure	Percent of Hispanic/Latino families that have children under 18 AND are female-headed	2005–2009 American Community Survey 5-year estimates
Hispanic population number	Number and percent of individuals of Hispanic/Latino origin	2010 Census
Hispanic population percent	Percent of total population that is of Hispanic/Latino origin	2010 Census
Home ownership	Percent of Hispanic/Latino households that are renter-occupied.	2005–2009 American Community Survey 5-year estimates
Hospitalization rate	Percent of Hispanic/Latino population hospitalized (excludes birthing patients)	Carolinas HealthCare System
Household income	Median household income for Hispanic/Latino households	2005–2009 American Community Survey 5-year estimates
Legal status	Percent of Latin American-born that are not U.S. citizens	2005–2009 American Community Survey 5-year estimates
Multi-generational families	Percent of Families with three or more generations.	2005–2009 American Community Survey 5-year estimates
Poverty	Percent of Hispanic/Latino families below the poverty level	2005–2009 American Community Survey 5-year estimates
Presence of children	Percent of Hispanic/Latino population that are under 18	2010 Census
Previous residence	Percent of Hispanic/Latinos (1 year and older) that moved from abroad in the past year	2005–2009 American Community Survey 5-year estimates
Safety net clinic use	Percent of Hispanic/Latino population using a safety net clinic	Carolinas HealthCare System
Time of arrival	Percent of Latin American-born that entered the U.S. in 2000 or later	2005–2009 American Community Survey 5-year estimates
Transportation	Percent of Hispanic/Latino workers (16 and over) who walk or take public transportation to work	2005–2009 American Community Survey 5-year estimates
Unemployment rate	Percent of Hispanic/Latino civilian labor force that are unemployed	2005–2009 American Community Survey 5-year estimates
Violent crime	Violent crime offenses per capita	Charlotte-Mecklenburg Police
Social Determinants of Health Measures not collected because data was not available at the census tract level for the Hispanic/Latino Population		
Access to parks/recreation centers		Mental health (Depression)
Access to technology		Quality of life - real and perceived

Social Determinants of Health Measures	Measure Definition	Data Source
Deportation rates		Religion
Domestic violence		Social support network
Gang membership		Types of employment/occupation

Note. Twenty-one measures and definitions included for the 20 social determinant concepts. The four variables in the Hispanic Health Risk Index are highlighted in grey. An additional 13 measures were identified that were not included because data was not available at the census tract level.

Table 3Social Determinants of Health included in principal component (Primary Care Barrier Index)^a

Social Determinants of Health^b	Correlation with principal component	Variance explained by principal component
Safety net clinic use	0.80	68%
English ability	0.74	58%
Legal status	0.73	68%
Hispanic population percent	0.71	51%
Access to public transportation	0.70	59%
Education level	0.69	49%
Homeownership	0.66	49%
Violent crime	0.66	65%
Hispanic population number (as % of max sample value of 3,174)	0.62	39%
Household income (as % of max sample value of \$250,001)	-0.60	38%
Family structure	0.54	39%
Hospitalization rate	0.51	27%
Acculturation	0.51	85%
Time of arrival	0.48	81%
Transportation	0.40	28%
Poverty	0.40	17%
Previous residence	0.26	9%
Total % of Variance Explained		37%^c

^a Access to grocery stores, Multi-generational families, Presence of children, and Unemployment rate were not included in the index because the loadings for these variables fell below the threshold for 0.25.

^b All variables captured as percentages or rates and are specific to the Hispanic/Latino population except for violent crime rate. Median household income and Hispanic population were scaled by dividing by the maximum value in the sample data. Correlation coefficients were all statistically significant with $p < 0.001$.

^c The eigenvalue for the principal component was 6.24.

Table 4

Associations of the Hispanic Health Risk Index and the Primary Care Barrier Index with use of emergency department for primary care reasons, from multivariate logistic generalized estimating equations.

	<u>Model 1: Hispanic Health Risk Index</u>	<u>Model 2: Primary Care Barrier Index</u>
Parameter	<i>OR</i> (95% CI)	<i>OR</i> (95% CI)
Index	1.106 (1.059, 1.156)	1.083 (1.035, 1.134)
Gender=Male	0.533 (0.492, 0.577)	0.534 (0.493, 0.578)
Age (per 10-point increase)	0.930 (0.991, 0.995)	0.928 (0.991, 0.994)
QICu ^a	16534	16408

^aQICu = quasi-likelihood under the independence model criterion; smaller values indicate better model fit. All *p* values were <0.001.