# Identification of Priority Areas for Increased Testing Using Geospatial Mapping of Incident HIV Cases Near Charleston, South Carolina

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**ABSTRACT:** Analysis of disease incidence using geospatial mapping techniques can enhance targeted public health efforts in resource-limited settings. While data for HIV incidence are readily available for some metropolitan regions, there is no existing resource that maps HIV incidence geospatially for Charleston, South Carolina and surrounding counties. To facilitate the public health approach to address the HIV epidemic in this region, we used data collected by the South Carolina Department of Health and Environmental Control (SC-DHEC) from 2014 to 2015 to generate local geospatial maps of disease incidence and identify specific areas that may benefit from increased testing and educational efforts. We identified specific zip codes in which there were a high number of cases from patients residing in those areas, but a low number of providers reporting new cases, and we describe ongoing efforts to address this disparity. This analysis identifies a local, collaborative approach to address the HIV epidemic using routinely collected surveillance data.

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## Introduction

Over 40% of persons living with HIV in the United States, and over 50% of all newly reported diagnoses occur in persons residing in southern states.[1]Based on 2015 data from the Centers for Disease Control and Prevention (CDC), South Carolina has the 11th highest incidence and prevalence of HIV in the country,[2,3] with the highest disease burden in black men who have sex with men, who have an estimated lifetime risk of 1 in 2 for acquiring HIV infection.[2,3] The Tri-County coastal region of South Carolina, comprised of Berkeley, Charleston, and Dorchester Counties, has high annual incident HIV infection rates (34, 13, and 12 per 100 000, respectively) relative to national averages (7.3 per 100 000; AIDSVU.org and cdc.gov 2013 data). Based on 2015 CDC data, only 83% of persons with HIV in South Carolina are aware of their status, which is below the national goal of 90%.[3] While the publicly accessible, online AIDSVu tool provides geographical data describing the spatial distribution of HIV in multiple metropolitan cities, including Columbia, South Carolina,[4] these data are not available for the Tri-County region surrounding Charleston.

Geographic disparities in access to HIV care exist disproportionately in the southern United States.[5] Delayed access to care can have critical effects on clinical outcomes, including a higher likelihood of developing AIDS, particularly in southern states.[6,7] The distance patients must travel to receive care can have a significant impact on the quality and timeliness of care they receive.[8] Innovative approaches are needed to identify, link, and provide care for those living with chronic HIV infection, particularly for those who reside in areas where HIV testing and clinical care are not available.

The Tri-County SHAPE (Sexual Health Awareness, STI Prevention, and Education) Initiative is a collaborative effort between South Carolina's Department of Health and Environmental Control (DHEC) and community and local organizations engaged in HIV and sexually transmitted infection (STI) testing, treatment, and promotion of sexual health awareness and education. This group was formed in 2015 to explore collective approaches to address the HIV, syphilis, and other STI epidemics in the Tri-County region. Using data routinely collected by DHEC as part of STI surveillance, we sought to develop a focused understanding of the geographic distribution of incident HIV cases in our region, to compare this to the availability of providers reporting new infections, and to identify areas that may benefit from increased testing resources and approaches to identify new infections.

## Methods and Materials

South Carolina state law requires physicians, hospitals, laboratories, and other health facilities to report newly diagnosed HIV infections to the DHEC to facilitate partner notification and referrals for medical and support services. De-identified quarterly DHEC data for newly reported HIV cases in South Carolina's Tri-County region, composed of

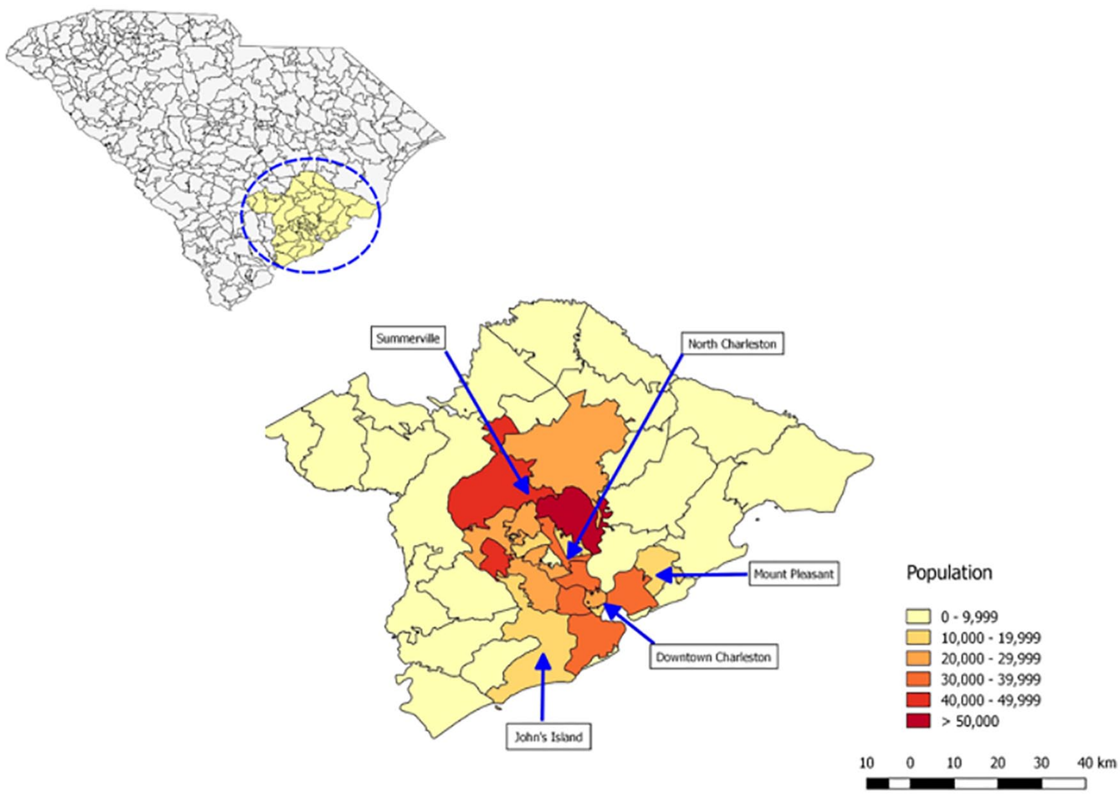



**Figure 1.** Population density of the coastal Tri-County region generated via QGIS Software. On the left is an image of South Carolina indicating location of the Tri-County region of Charleston, Dorchester, and Berkeley Counties. On the right is an image of only these counties with lines separating different zip codes. To facilitate orientation of this map, we include light blue arrows and labels to indicate major cities in the region. The legend indicates color coding of total population for each individual zip code.

Berkeley, Charleston, and Dorchester counties (Figure 1), were obtained from SC-DHECs Division of Surveillance & Technical Support for the calendar years 2014-2015 and combined into a single dataset to facilitate analysis. Data were available as total number of cases per zip code, and precise geospatial data for individual cases were not available or used. Zip code data boundaries in the Tri-County region were obtained from www.us-zip.org (Supplemental Figure 1A). Total population data for individual zip codes within the Tri-County region were obtained from www.unitedstateszip-codes.org/zip-code-database/ (based on 2010 census data, data downloaded May 2016). For an analysis of urban versus rural distribution of data, urban was defined using the United States Census Bureau[9,10] definitions from 1995 based on total population thresholds, density, land use, and distance for a given area (Supplemental Figure 1B). Names of practices reporting new HIV cases were obtained from SC-DHEC, and the mailing address for these providers was used as their location for GIS mapping to the level of zip code. Data for individual zip codes include only those providers reporting at least one case during the indicated time period, as providers reporting no cases are not represented in the SC-DHEC dataset. A list of providers offering free or reduced fee HIV testing as of 2016 was also compiled using referral sources known to SC-DHEC, online health care directories, and telephone interviews with local health care providers and medical offices (Supplemental File 1).

Because certain downtown Charleston zip codes (29401, 29403, and 29425) identify specific business locations or very small geographical areas, they were combined into one dataset for analysis and are reported under zip code 29403 (Supplemental Figure 1C). For large providers (including the Medical University of South Carolina, Roper St. Francis Healthcare, and Fetter Health Care Network) with multiple satellite practice locations where testing was performed, satellite site-specific data were obtained from DHEC to accurately assess geographic patterns of testing. Demographic information (age, race, sex, and zip code of residence) for the cohort are shown in Table 1 and are consistent with known demographics of HIV infection in the South.[1]

Using these data sources, we calculated (a) the total number of providers within each zip code who reported at least one case, (b) the total number of cases reported by all providers with a location practice within each zip code, (c) the total population per zip code, and (d) the total number of cases reported per zip code based on patient residence. In this study, HIV prevalence was not considered. Because testing data were only available for locations that use the South Carolina Bureau of Labs (such as health departments and DHEC-funded community-based partners) and were unavailable from private and

**Table 1.** Demographics of total HIV cases for Tri-County region including Charleston, South Carolina, 2014-2015.

| TOTAL CASES (2014-2015) | HIV 268 |
|---|---|
| Age (years) | |
| 0-19 | 17 |
| 20-24 | 59 |
| 25-29 | 56 |
| 30-39 | 53 |
| 40+ | 83 |
| Race | |
| Black | 190 |
| White | 63 |
| Other | 15 |
| Sex | |
| Female | 43 |
| Male | 225 |
| Other | |
| MSM | 162 |

Abbreviation: MSM, men who have sex with men.

academic practices, an analysis of testing patterns and practices could not be performed.

Data were organized using Microsoft Excel and then integrated and stratified with QGIS software (version 2.16.3; QGIS Development Team, 2016). A comparative analysis was performed in QGIS using maps denoting zip code boundaries within the Tri-County region, including spectrum shading as a visual representation of the examined variables. This study received approval from the Institutional Review Board at the Medical University of South Carolina.

## Results

To identify geographic areas in the Tri-County region that may benefit from increased access to HIV testing services, we examined trends in SC-DHEC HIV surveillance data based on patient and provider zip code in relation to population density for 2014-2015. Population density per zip code and landmarks providing spatial orientation and reference for South Carolina's Tri-County region are shown in Figure 1. An examination of the number of cases compiled by patient zip code residence, the number of providers per zip code reporting cases, and the number of free/sliding scale providers per zip code showed good overall concordance (Supplemental File 2).

To better evaluate these data geographically, we used QGIS software to visualize spatial distribution of cases. While the zip code residence of patients with newly diagnosed HIV mirrored overall population density (Figure 2A), when cases were graphed by zip code location of providers making new HIV diagnoses, there was less geographic breadth (Figure 2B). This comparison identified multiple zip codes where patients with newly diagnosed HIV infection resided but where no new cases were reported by providers working in these locations. An examination of the total number of providers in each zip code reporting at least 1 case (Figure 2C) and the number of providers per zip code offering free or reduced fee HIV testing (Figure 2D) also identified specific zip codes with a potential shortage of providers performing testing, even though patients newly diagnosed with HIV resided in those areas. As stated in the "Methods and Materials" section, because we did not have access to testing practices from all providers, we cannot distinguish whether zip codes with low provider reporting reflect testing practices (ie, missed opportunities for testing and thus opportunities for education) or a lack of clinical encounters where testing was felt to be relevant.

To better understand these data, and to identify specific regions that could benefit from increased testing, we analyzed and graphed the data based on the ratio of the number of providers per zip code reporting cases to the number of cases (Figure 3A and B). A ratio of 0.3 was chosen to demarcate each zip code into either a low provider to patient ratio ($<0.3$) or high provider to patient ratio ($>0.3$) (Figure 3). Several zip codes in the North Charleston, Ladson, and Summerville regions (eg, 29418, 29420, 29456, and 29485) were found to have multiple patient cases, but few cases reported by a provider in those areas (Figure 3). Geospatially, these data from adjacent zip codes identified an area between Summerville and downtown Charleston with a high number of cases but potentially less access to testing, suggesting patients in this area may have had to travel outside of their immediate zip code to access testing services.

Because zip codes in the Tri-County region with low population density also had low number of reported cases and providers reporting cases, we also examined the data based on bimodal classification of zip codes as urban or rural based on population numbers, as described in the "Methods and Materials" section and as shown in Supplemental Figure 1B. We found that while there are a comparable total number of persons living in urban versus rural zip codes in the Tri-County region, there were significantly more cases reported by patient residence or provider location zip code in urban areas (Table 2), suggesting either a lower burden of disease in rural areas or a need for increased access to testing to identify new cases.

## Discussion

This geospatial analysis of incident HIV cases in SC's Tri-County region identified specific zip codes where there were high numbers of persons with newly diagnosed HIV infection resided, but where there were a low number of providers

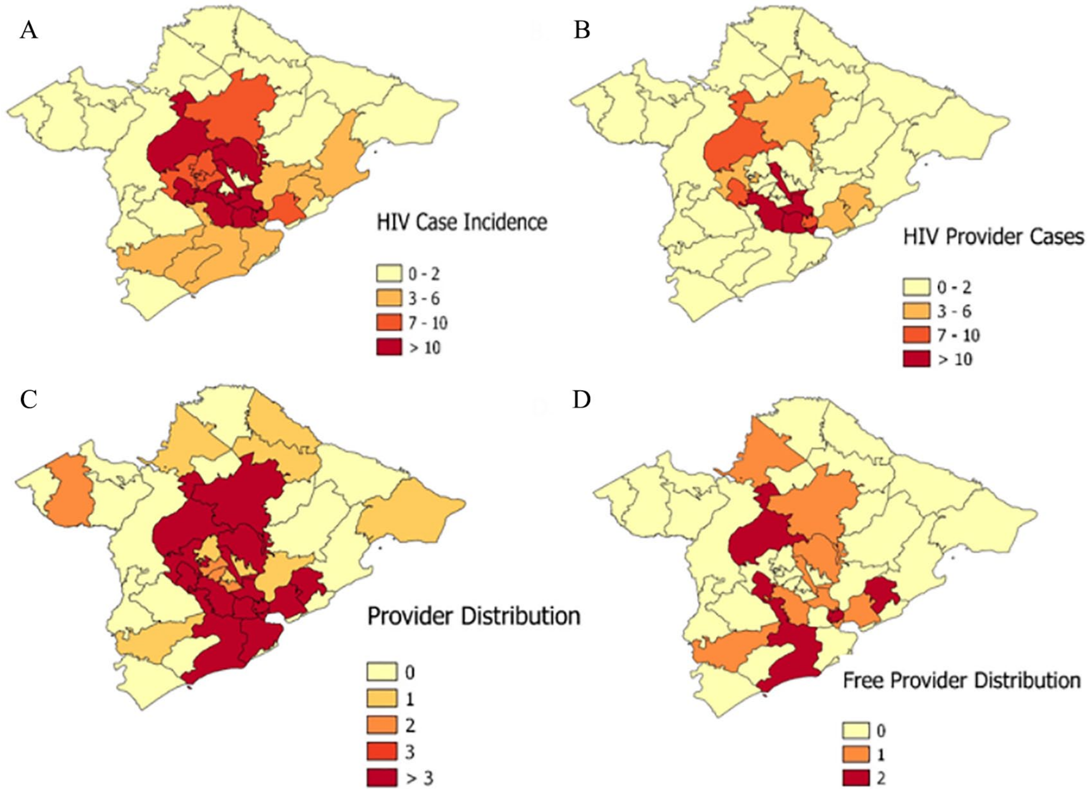
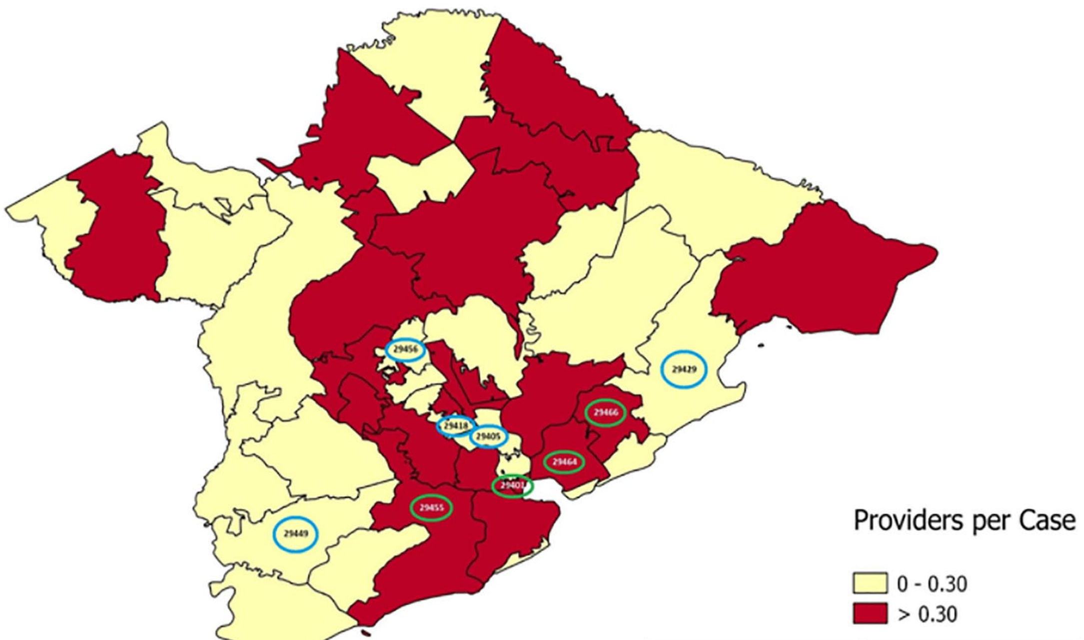



**Figure 2.** Geospatial representation of HIV cases and providers. Shown are (A) the number of incident HIV cases per zip code of patient residence, (B) the number of cases reported by providers based on provider zip code location, (C) the total number of providers reporting at least one case in each zip code, and (D) the number of providers who offer free or sliding scale HIV testing per zip code.




| Low Provider to Case Ratio | | High Provider to Case Ratio | |
|---|---|---|---|
| 29405 | 0.15 | 29464 | 1.25 |
| 29418 | 0.14 | 29401 | 1.75 |
| 29456 | 0.11 | 29466 | 1.20 |
| 29449 | 0.17 | 29455 | 1.33 |
| 29429 | 0.00 | 29477 | 1.00 |

**Figure 3.** Identifying specific zip codes with high number of cases and lower numbers of available testing options. Distribution of zip codes with low (<0.3) vs high (>0.3) provider to patient ratios. Zip codes with the highest and lowest ratios are highlighted with data represented in the inset table.

Table 2. Urban vs rural analysis of population and incident HIV cases based on patient and provider zip code.

| | RURAL | URBAN | RATIO | *P* VALUE |
|---|---|---|---|---|
| Total population | 618 537 | 735 880 | .84 | |
| Cases by patient zip code residence | 28 | 234 | .12 | <.0001 |
| Cases by provider zip code location | 4 | 232 | .01 | <.0001 |

Statistics were calculated by chi-square analysis.

reporting cases from these zip codes. Furthermore, the data highlight the significantly lower number of new diagnoses being made in rural relative to urban zip codes. Together, these data suggest that individuals newly diagnosed with HIV living in zip codes without reporting providers may need to travel some distance for testing services, identifying a potential barrier to testing for those who have undiagnosed HIV infection in these areas. The regions identified in this analysis will benefit from efforts to increase access to HIV testing. This approach to analyzing local HIV surveillance data can facilitate efforts to help end the HIV epidemic by identifying priority areas for public health efforts.

The relatively lower number of new cases reported by providers in rural zip codes suggests that new diagnoses for patients living in these areas are likely not made by providers in those areas and that increased resources for testing in rural zip codes would be beneficial. One caveat to this interpretation is that DHEC Disease Intervention Specialists occasionally draw blood in the field when interviewing the partner of an HIV client, which is then sent to a DHEC clinic that may be in an urban zip code. While this could influence the data reported here, this only represents a handful of clients each year and is unlikely to change the overall pattern we observed. Whether the low number of cases reported in persons residing in rural zip codes is a reflection of true burden of disease versus underdiagnosis of existing cases requires further evaluation and cannot be answered by this dataset.

As an example of how geospatial data analyses such as this can impact public health action, Palmetto Community Care (PCC, formerly known as Lowcountry AIDS Services), an HIV Community–Based Organization and SHAPE partner, used this and other data in efforts to target underserved areas in the Tri-County region for HIV testing in zip codes 29406, 29407, 29412, 29445, 29455, 29466, and 29483. In addition, PCC mobile testing van services were initiated in 2018 to reach outlying communities with limited existing public health infrastructure, including those identified in this GIS analysis.

The major limitation of the study is that we lacked precise geospatial data for individual cases that precluded more precise geospatial proximity and distance to service analyses. Nonetheless, analysis of composite data at the level of zip code allowed for important insights to be gained that can be built on in subsequent analyses.

In summary, using data routinely collected by SC-DHEC, we performed a geospatial analysis of incident HIV cases in a Southern metropolitan region that can be used as a practical tool to help guide public health efforts to target the HIV epidemic. This approach is amenable to adaptation in other areas where geospatial mapping of cases has not yet been performed. Regular updating of these maps over time will facilitate our understanding of incidence trends and facilitate informed interventions longitudinally.

## Acknowledgements

We acknowledge the contributions of the Tri-County Sexual Health Awareness, (STI) Prevention, & Education (SHAPE) Initiative—a public health community collaborative formed in 2015 focused on sexual health disparities for at-risk populations in Berkeley, Charleston, and Dorchester Counties of South Carolina. We would also like to acknowledge resources and data provided by the South Carolina Department of Health and Environmental Control (SC-DHEC) Division of Surveillance and Technical Support and leadership from the agency's Tri-County region Public Health Regional Office which were integral to this work.

## Author Contributions

RG and EGM conducted the primary data analysis. RG, KBW, AO, ML, KJR, and EGM performed data collection and participated in interpretation of the data and preparation of the manuscript.

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## Supplemental Material

Supplemental material for this article is available online.

## REFERENCES

1. CDC. HIV in the Southern United States. https://www.cdc.gov/hiv/pdf/policies/cdc-hiv-in-the-south-issue-brief.pdf. Updated May 2016.
2. CDC. Diagnosis of HIV infection in the United States and dependent areas, 2014. https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-us.pdf.
3. CDC. HIV surveillance report, 2015. https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2015-vol-27.pdf.
4. AIDSVU.org.
5. Kimmel AD, Masiano SP, Bono RS, et al. Structural barriers to comprehensive, coordinated HIV care: geographic accessibility in the US South. *AIDS Care*. 2018: 1459-1468.

6. Krawczyk CS, Funkhouser E, Kilby JM, Vermund SH. Delayed access to HIV diagnosis and care: special concerns for the Southern United States. *AIDS Care*. 2006;18:S35-S44.
7. Robertson M, Wei SC, Beer L, et al. Delayed entry into HIV medical care in a nationally representative sample of HIV-infected adults receiving medical care in the USA. *AIDS Care*. 2016;28:325-333.
8. Cope AB, Powers KA, Serre ML, et al. Distance to testing sites and its association with timing of HIV diagnosis. *AIDS Care*. 2016;28:1423-1427.
9. https://www.census.gov/geo/reference/urban-rural.html. Accessed 2016.
10. U.S. Census Bureau. Selected housing characteristics, 2007-2011 American community survey 5-year estimates. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_DP04. Updated 2011.