## Title

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Journal
Cancer Causes & Control, 24(12)

ISSN
0957-5243

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Publication Date
2013-12-01

DOI
10.1007/s10552-013-0286-x

Peer reviewed

Published in final edited form as:
*Cancer Causes Control*. 2013 December ; 24(12): . doi:10.1007/s10552-013-0286-x.

# Are HPV vaccination services accessible to high-risk communities?: A spatial analysis of HPV-associated cancer and Chlamydia rates and safety-net clinics

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## Abstract

**Purpose—**While HPV vaccines can greatly benefit adolescents and young women from high-risk areas, little is known about whether safety-net immunization services are geographically accessible to communities at greatest risk for HPV-associated diseases. We explore the spatial relationship between areas with high HPV risk and proximity to safety-net clinics from an ecologic perspective.

**Methods—**We used cancer registry data and Chlamydia surveillance data to identify neighborhoods within Los Angeles County with high risk for HPV-associated cancers. We examined proximity to safety-net clinics among neighborhoods with the highest risk. Proximity was measured as the shortest distance between each neighborhood center and the nearest clinic and having a clinic within 3 miles of each neighborhood center.

**Results—**The average 5-year non-age-adjusted rates were 1,940 cases per 100,000 for Chlamydia and 60 per 100,000 for HPV-associated cancers. A large majority, 349 of 386 neighborhoods with high HPV-associated cancer rates and 532 of 537 neighborhoods with high Chlamydia rates had a clinic within 3 miles of the neighborhood center. Clinics were more likely to be located within close proximity to high-risk neighborhoods in the inner city. High-risk neighborhoods outside of this urban core area were less likely to be near accessible clinics.

**Conclusions—**The majority of high-risk neighborhoods were geographically near safety-net clinics with HPV vaccination services. Due to low rates of vaccination, these findings suggest that while services are geographically accessible, additional efforts are needed to improve uptake. Programs aimed to increase awareness about the vaccine and to link underserved groups to vaccination services are warranted.

### Keywords

human papillomavirus; HPV-associated cancers; HPV vaccine; cancer registry; geographic information systems (GIS)

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## INTRODUCTION

Recent reports indicate that while overall cancer incidence and mortality rates have declined over the past few decades, a steady rise in the incidence of many HPV-associated cancers has been observed in recent years [1, 2]. It is estimated that approximately 34,200 new cases of HPV-associated cancers, of the cervical, vulvar, vaginal, anal, penile, and oropharyngeal sites, are diagnosed annually [1, 2]. The majority of all HPV-associated cancers for women are cervical cancers (53%) and the majority of cases for men are oropharyngeal cancers (78%) [1]. Data from the past two decades have shown that cervical cancer disproportionately burdens low-income and racial/ethnic minority women in the United States [3–6]. Although many studies link cervical cancer disparities to low socioeconomic status, limited access to health care, and lack of awareness, an increasing number of studies also consider the unequal burden of cervical cancer to be markers of larger social inequalities rooted in the context of geographically-based characteristics [5, 7–11]. Data on other HPV-associated cancer rates also indicate emerging disparities by race/ethnicity and socioeconomic status [12, 13].

Two available HPV vaccines (quadrivalent and bivalent) provide an effective strategy for the prevention of cervical cancer and other HPV-related cancers among adolescents and young adults [14, 15]. Both vaccines protect against infections of two high-risk HPV-types (16 and 18) that are responsible for over 70% of all cervical cancer cases worldwide [16] as well as the development of other HPV-related cancers at the vulvar, vaginal, anal, penile, and oropharyngeal sites [12]. The Advisory Committee on Immunization Practices (ACIP) recommends routine HPV vaccination for adolescents ages 11 to 12 and catch-up vaccination for young women up to age 26 and young men up to age 21 [17]. To date, however, HPV vaccine uptake has been suboptimal in all groups [18], thereby limiting the full potential benefit of the vaccines. Furthermore, without adequate vaccine uptake among communities that have traditionally lower rates of cervical cancer screening and higher rates of HPV-associated cancers, disparities may continue or worsen between subgroups [19].

In Los Angeles County, free or low-cost HPV vaccines can be accessed by low-income populations through safety-net clinics affiliated with the county’s immunization referral program. All clinics on the referral list receive federal funding from the Centers for Disease Control’s Vaccines for Children (VFC) program to provide free vaccines to low-income children [20]. In addition, many clinics also receive funding to subsidize vaccination costs for underinsured children [21]. While safety-net clinics are traditionally located in underserved low-income areas, little is known about whether these safety-net services are located within or in close proximity to communities at high-risk for HPV-associated diseases. Two recent studies that examined HPV vaccination among adolescents from high-risk communities in Los Angeles County showed low vaccination rates [22, 23] and revealed that parental awareness of the vaccine [22] as well as a provider recommendation [23] were associated with increased uptake. Neither study, however, examined whether these high-risk communities were within an accessible distance to safety-net immunization services.

Geographic accessibility, or proximity, to health care has been shown to impact utilization of various health services, including HIV testing, asthma management, breast cancer screening, and childhood immunizations [24–29]. A study by Fu and colleagues found that low-income, urban children living closer to pediatricians were more likely to be up to date with childhood vaccinations [25]. Other studies have shown that geographic accessibility to health-related resources, including safety-net clinics, food stores, and open space, are not equitable across racial/ethnic groups or socioeconomic status [30–35]. Zenk and colleagues, for example, revealed that neighborhoods with greater proportions of minorities were further away from safety-net mammography services compared to neighborhoods with higher proportions of non-Hispanic whites [36].

Although safety-net clinics are known to be concentrated in disadvantaged neighborhoods, it is unclear whether all areas with high HPV-associated cancer risk are served by these services. Furthermore, while prior studies have assessed the geographic relationships between county level cervical cancer rates and incidence or mortality, few have focused on rates at the neighborhood level to assess the need for HPV vaccination services [8, 37–39]. This study examines the location of low-income neighborhoods with high HPV-associated cancer risk and whether these neighborhoods are in close proximity to safety-net immunization clinics that provide free or low cost HPV vaccination services.

## METHODS

We conducted an ecologic cross-sectional spatial analysis using cancer registry data, Chlamydia surveillance data, and locations of safety-net clinics providing immunizations to low-income populations to determine whether neighborhoods with high HPV risk have access to HPV vaccination services. We used census tracts, which include an average of 4,000 people, in Los Angeles County (n=2,052) as neighborhood boundaries in this study. A vast number of empirical studies examining contextual or neighborhood effects on health exist, but consensus is limited on the appropriate spatial scale used to determine area-level influences on health [40–44]. Prior studies have shown that census-tract level neighborhood data provide the most sensitive measures of neighborhood health disparities and are most easily linkable to other datasets [45].

### Data

**Neighborhood HPV risk—**Currently, no systematic surveillance program exists for HPV infected cases in Los Angeles County. As an alternative, we use five-year incidence rates of HPV-associated cancers and Chlamydia for each census tract in the county as proxy measures for neighborhood level risk of HPV infection. Overlapping risk factors exist for acquiring Chlamydia and HPV infections [46]. Emerging data also show Chlamydia infection serves as a cofactor for developing cervical cancer as it increases the risk for persistent HPV infection [47–49]. Furthermore, Chlamydia infection rates have been used to identify populations at high-risk for cervical cancer in other epidemiologic studies [37, 50]. We obtained the five most recent years of STD incidence data (2005–2009) available for Chlamydia from the Los Angeles County Department of Public Health’s Sexually Transmitted Disease (STD) Program. Active and passive surveillance of reportable STDs, including Chlamydia, are routinely conducted by the county’s STD program. Chlamydia cases were provided for census tracts with greater than 5 cases during the five year period. Chlamydia counts were divided by each census tract’s population size to obtain smoothed 5-year non-age-adjusted incidence rates.

We obtained corresponding five year incidence rates of HPV-associated cancers from the Los Angeles County Cancer Surveillance Program (CSP), a member of the California Cancer Registry and the National Cancer Institute’s Surveillance, Epidemiology, and End Results program [51]. The following sites were included in the analyses: cervix, vagina, vulva, penis, anus, anal canal & anorectum, oropharynx. These cancers have been linked as etiologic outcomes of persistent high-risk HPV infections. Addresses of cases diagnosed between 2005 and 2009 were geocoded to obtain the latitude and longitude. To maintain spatial confidentiality [52], each of these points was smoothed using the kernel density tool in ArcGIS 10 to create continuously color-shaded maps showing the density of cases (number of cases) per square kilometer in Los Angeles County neighborhoods. To obtain mean cancer cases within each census tract, these kernel density maps of HPV-associated cancers were then intersected with the census tract layer using zonal statistics in ArcGIS 10. Estimated means were divided by each census tract's population size to obtain 5-year non-age-adjusted incidence rates of HPV-associated cancer.

**Safety-Net Immunization Clinics—**All clinic sites (n=155) from the Los Angeles County Department of Public Health (LACDPH) Immunization Program's referral list that provide free or low cost vaccines were included in the analysis. These clinics encompassed health centers operated by Los Angeles County (e.g. county hospitals, comprehensive health centers), private-public partnership clinics (i.e. federally qualified health centers, community health clinics, other private clinics that target underserved populations), and some school-based health centers that were identified by the LACDPH Immunization Program. These 155 clinics serve as major points of access to primary care services, including receiving immunizations, for low-income populations within Los Angeles County. Addresses for clinics were obtained through the LACDPH website and confirmed with the Immunization Program. All clinics were geo-coded using ArcGIS 10 (ESRI, Redlands, CA).

**Neighborhood Socio-demographic Characteristics—**We used the 2005–2009 multi-year American Community Survey (ACS) data, collected by the U.S. Census Bureau, for neighborhood socio-demographic variables [53, 54]. This data are temporally aligned with the Chlamydia and HPV-associated cancer rates used for neighborhood risk. Neighborhood level socio-demographic data from the ACS included percent living below poverty, percent with less than a high school education, percent with no access to a private vehicle, percent white, percent African American, percent Asian, percent Latino, percent non-citizen, and percent linguistically isolated (any language) for each census tract.

## Measures

The primary outcome for this study was neighborhood geographic access to HPV vaccination services. We operationalized geographic access using the definition for health care accessibility provided by Pechansky and Thomas: "the relationship between the location of supply and the location of clients, taking into account client transportation resources and travel time, distance and cost [55]. " Locations of safety-net immunization clinics were spatially joined with census tracts to obtain two different geographic access measures. Prior studies have shown that census-tract level neighborhood data provide the most sensitive measures of neighborhood health disparities and are most easily linkable to other datasets, however, there is limited concensus in the literature regarding the most appropriate unit of analysis. The first measure was shortest distance (in miles) between the geographic centroid of each census tract and the nearest safety-net immunization clinic. Only geographic weighted centroids were used as population weighted centroids were not available from the data. We used straight-line (Euclidean) distance rather than distance over the road network because we were generalizing access from a neighborhood level. A dichotomous (yes/no) variable was also constructed for whether at least one immunization clinic existed within a 3-mile radius of each neighborhood's geographic centroid. Several prior studies have suggested the average distance to health care facilities in urban areas is between 2 to 5 miles [25, 29, 33]. This study started with a 3-mile radius but also examined 1-mile and 5-mile radii as a sensitivity analysis. The dichotomous measures were obtained using the buffer, overlay, and spatial join tools in ArcGIS10.

The primary predictor for this study was neighborhood risk as measured by rates of Chlamydia and HPV-associated cancers. A hot spot analysis was conducted using the Getis-Ord hot spot tool in ArcGIS 10 to determine areas with significantly higher or lower rates of Chlamydia and HPV-related cancers separately. The hot spot analysis tool in ArcGIS 10 identifies spatial clusters of significantly high values (hot spots) and low values (cold spots) within the context of neighboring features (i.e. census tracts) using z-scores and p-values of the Getis-Ord Gi* statistic [56]. We plotted the Moran's I statistic for a range (0.25 to 8 miles) of distance bands to identify the critical distance that for the cluster analysis. This critical distance (approximately 5000 meters or 3 miles) represents the threshold where additional neighbors would not make an impact on the spatial relationship of interest. We used the zone of indifference with the above critical distance to conduct the hot spot analysis. For Los Angeles County, this distance band results in more neighbors for densely populated, geographically small census tracts within the central inner city area and far fewer neighbors for less densely populated, geographically large census tracts in more peripheral areas. Hot spots in areas with geographically larger census tracts may be less stable due to their reliance on just a few neighbors for the cluster analysis. Census tracts were categorized into high-risk (hot spots with significantly higher rates, positive z-scores and p-values <0.05), medium risk (hot spots with positive or negative z-scores and non-significant p-values), and low risk (cold spots with significantly lower rates, negative z-scores and p-values <0.05). The primary interest of this analysis was to examine whether neighborhoods with high cervical cancer risk have access to safety-net clinics, and thus risk was dichotomized into high versus medium/low categories for the multivariable adjusted analysis.

### Statistical Analysis

Initial descriptive statistics were conducted to profile the study sample and to examine the distribution of neighborhood characteristics across high, medium, and low categories of 5-year unadjusted Chlamydia and HPV-associated cancer rates. Distance to nearest clinic was log transformed based on univariate distributions. Neighborhood characteristics for hot spots with and without clinics within 3 miles were also calculated. Unadjusted associations between distance to clinic and predictor variables were examined using ordinary least square regression methods in the spatial statistics toolbox in ArcGIS 10. Significant associations were determined using robust standard errors at the p<0.05 level. Unadjusted associations for the dichotomous access measure (clinic within 3 miles) were examined using logistic regression methods in STATA v 10.

Multivariable ordinary least squares regression models were conducted in ArcGIS 10 to assess the relationship between the distance measure of neighborhood spatial access and neighborhood cervical cancer risk while controlling for other neighborhood socio-demographic factors. Geographic model fit statistics were obtained from ArcGIS to assess spatial autocorrelation and potential geographic variability in adjusted relationships. To account for spatial autocorrelation, robust standard errors were used to identify significant coefficients at the p<0.05 level. As a sensitivity analysis, we explored a geographic weighted regression method in ArcGIS 10 to see if the relationship between hot spots and distance to nearest clinic differed across regions. For the dichotomous measures of access (clinic within 3 miles), a logistic regression model using robust standard errors was conducted in STATA v10. Coefficients from the multivariable regression models for neighborhood level variables with a 0–100% scale were standardized for better ease of interpretation. Statistical significance for beta coefficients in the final regression model were also determined at the p<0.05 level.

## RESULTS

The average 5-year Chlamydia incidence rate per census tract was 1,940 cases per 100,000 (Std. Dev=1700 per 100,000). The average 5-year HPV-associated cancer incidence rate per census tract was 60 cases per 100,000 (Std. Dev=240 per 100,000). The maps representing results from the hot spot analyses for Chlamydia and HPV-associated cancers are shown in Figures 1 and 2. Most areas with significantly high rates of Chlamydia and HPV-associated cancers are located in central Los Angeles County, near the urban and downtown areas. Additional pockets of high-risk communities exist in the southern portion of the county in the Long Beach area as well as in the San Fernando Valley area. Shaded areas indicate census tracts with > 25% of residents living below poverty. These maps also indicate most hot spots with high poverty (>25%) are in close proximity to safety-net immunization clinics and that some hot spots in less impoverished areas may face some limited access to clinics. Although prior studies showed that increased poverty is correlated with higher rates of STDs [50], Figure 1 indicates not all areas in Los Angeles County with high Chlamydia rates are highly impoverished. Furthermore, areas with high HPV-associated rates did not fully overlap with high Chlamydia rate areas.

Table 1 shows neighborhood socio-demographic characteristics and distance to nearest clinic by HPV risk category, where hot spots in Figures 1 and 2 were categorized as high-risk areas and cold spots were categorized as low risk areas. A total of 386 census tracts were hot spots for significantly higher 5-year rates of Chlamydia. The average 5-year rate of Chlamydia per census tract among hot spots was 4,100 per 100,000. A total of 536 census tracts were hot spots for significantly higher 5-year rates of HPV-associated cancers. These high-risk areas had an average HPV-associated cancer rate of 130 per 100,000. The average distance to the nearest safety-net immunization clinic among high-risk neighborhoods was 1.14 miles compared to 1.92 miles and 2.31 miles for medium and low risk neighborhoods respectively. While these findings show an inverse relationship between neighborhood risk and distance to services, the absolute difference in distances between risk categories were minimal and effects of these differences in service use warrants further investigation. Overall, high-risk neighborhoods had significantly higher rates of residents living below poverty, with less than a high school education, and no access to a private vehicle compared to medium and low risk neighborhoods. Additionally, high-risk neighborhoods had more Latino, African American, non-citizen, and linguistically isolated residents compared to low risk areas. Larger differences in the composition of racial/ethnic groups between the high and low risk areas were seen in Chlamydia compared to HPV-associated cancers. In other words, the percentage point difference between the proportions of African American and Latino residents in high and low risk areas for Chlamydia were much greater (Latino: 65.3% vs 15.4 %, African American: 24.7% vs. 2.3%) compared to the differences in proportions between low and high-risk areas among the same groups for HPV-associated cancers (Latino: 55.6% vs. 44.6 %, African American: 13.3% vs. 4.5%). These differences may suggest Chlamydia hot spots primarily encompass ethnic minority neighborhoods while HPV related cancer hot spots overlap in both ethnic minority neighborhoods as well as some non-ethnic minority neighborhoods.

Among the 386 census tracts that were high-risk based on Chlamydia rates, only 5 did not have a clinic within at least 3 miles of each census tract’s centroid (data not shown). Among the 536 census tracts that were high-risk based on HPV-associated cancer rates, 37 did not have a clinic within at least 3 miles of each census tract’s centroid (data not shown). These census tracts with limited geographic access to clinics were less disadvantaged (e.g. lower rates of poverty, fewer residents with less than high school education, fewer linguistically isolated residents) than tracts with greater access to clinics, suggesting clinics are located in the most underserved areas based on socioeconomic needs. Only two high-risk census tracts with limited geographic access to clinics were located in impoverished areas (>25% living below poverty). These high-risk low-income areas were located in the outer periphery of the poor urban core of the county.

Results for adjusted and unadjusted linear regression models for distance to nearest clinic (log transformed in miles) using hotspots of 5-year HPV-associated cancer and 5-year Chlamydia incidence rates as primary predicators are shown in Tables 2 and 3, respectively.

The unadjusted analyses showed hot spots and all socio-demographic factors (aside from percent White and percent Asian) to be inversely associated with log-distance to clinics, indicating that neighborhood disadvantage and HPV risk were significantly associated with being closer to a clinic. Similar results were seen for logistic regression results for having a clinic within a 3-mile radius of the census tract centroid (data not shown). Robust standard errors were used to account for spatial autocorrelation and to identify significant coefficients conservatively at the $p<0.05$ level. After controlling for neighborhood socio-demographic factors in the model with neighborhood socioeconomic factors only and the full model with neighborhood socioeconomic factors and racial/ethnic composition factors, Chlamydia and HPV-associated cancer hot spots no longer remained significantly associated with distance to clinic. Findings from the geographically weighted analysis showed a negative relationship between distance to clinic and HPV risk within the inner city areas and a positive relationship between distance to clinic and cervical cancer risk in more suburban areas outside the county's center. In inner city areas, clinics were more likely to be located within or in close proximity with high-risk neighborhoods. However, high-risk neighborhoods peripheral to the inner city were less accessible to (i.e. further away from) clinics.

## DISCUSSION

This is one of the few studies that explored HPV-associated disease risk at the neighborhood level and its relationship to HPV vaccination services. Study findings indicate very few high-risk neighborhoods lack geographic access to HPV vaccination services through safety-net clinics in Los Angeles County, which is encouraging. The majority of neighborhoods with the highest risk were primarily located in the central urban areas of the county. These areas happen to overlap with low-income areas that have substantial numbers of safety net clinics. However, our findings did reveal two specific low-income neighborhoods that were not well served with respect to safety-net immunization services. Both neighborhoods were located outside of the primary urban core of the county. Data from the 2000 and 2010 census indicate that these areas experienced about a 10% poverty increase between the 10 year period and an even greater increase in the proportion of single female headed households within the same time period. These changing characteristics suggest safety-net services may be increasingly needed within newly emerging areas of concentrated poverty where HPV risk is high.

It also is important to note that while the majority of low-income neighborhoods had accessible safety-net clinics, many low-income residents who live in less impoverished neighborhoods may face greater geographic barriers to accessing safety-net immunization services compared to their counterparts living in more disadvantaged neighborhoods. These suburban poor may experience increased geographic barriers related to accessing safety-net clinics [10, 57–60] and therefore, have a greater reliance on private physicians' offices for immunization services. Private physician's offices face low reimbursement rates for vaccination services, which have been shown to impact physician recommendation for vaccines [59, 60]. Our prior work examining HPV vaccination among adolescent girls, which showed lower uptake among low-income girls in neighborhoods with low or moderate poverty compared to girls in living in the most impoverished neighborhoods, further support this trend [61]. Additional focus on promoting HPV vaccine uptake needs to be made on the growing suburban poor outside the traditional safety-net catchment areas.

Although immunization services are geographically available and costs are reduced through the VFC program, the low uptake of HPV vaccines among adolescent girls seen in our study and in nationally reported rates suggest the need to explore other health care organizational factors that may serve as barriers to vaccination. For example, lack of in-language services and limited clinic hours may prevent high-risk communities from accessing services even if they are geographically available. Additionally, factors on the provider side, including recommending the vaccine [62], coupling HPV vaccination with other office visits [63], and reminder systems for on-time vaccinations [64] may enhance uptake of the vaccine. Several studies have shown provider recommendation [50, 60] and missed opportunities [63, 65] as factors that can be improved upon for increasing HPV vaccine uptake. Recent studies have also shown support for adolescent vaccination services to be delivered via school-based health clinics or other community-based centers [66]. Lastly, other political avenues aimed to increase preventive care, including health care reform and potential school mandates, may have a larger impact than geographic proximity of safety-net vaccination services on improving uptake rates. For example, a recent study conducted among parents of adolescent girls from high-risk communities in Los Angeles County showed more than half of parents supported a school mandate for HPV vaccination [67]. Additionally, implementation of the Affordable Care Act (ACA) will place stronger emphasis on establishing medical homes and community-based collaborative care networks. These changes may increase adherence to recommended vaccinations overall, including HPV vaccination [68, 69].

Some limitations should be mentioned. First, neighborhoods in this study were defined by census tracts and accessible distances to clinics were predetermined at 3-miles. Although census tracts have been used in several other studies that examine the influence of neighborhood factors on health, validity of census tracts as a construct for neighborhoods has not been extensively studied for multiple racial/ethnic groups [70]. Little is known about whether definitions of neighborhoods differ by race/ethnicity [41] and whether certain groups prefer to use health services near ethnic community centers outside of their immediate neighborhood. Second, incidence rates of HPV-associated cancer at the census-tract level were calculated using density estimates of cases, and were not directly based on actual counts of cases. We recommend that caution be exercised when interpreting individual rates resulting from this method. However, we used these rates to categorize census tracts into high, medium and low risk. The risk designations would be, arguably, similar to those produced using incidence rates based on actual counts of cases. We examined the same cancer sites as other national studies on HPV-associated cancers, however, it should be noted that while persistent HPV infection is associated with all of these cancer sites, other risk factors, including smoking and alcohol, are also contributors of these HPV-associated diseases. Third, although we used distance to services as one measure of health care access, other organizational and system aspects of care, such as wait times, language concordant care, and clinic capacity, may also impact the availability and access of safety-net immunization services. Lastly, this ecological study is unable to identify causal relationships between individual geographic access to clinics and uptake of the HPV vaccine.

Our study provides insight for within county-differences related to spatial patterns of HPV-associated diseases that exist within a large, diverse urban context. Our findings suggest that efforts to improve the reach of county cancer control services should focus on existing programs rather than increasing the number of access points for safety-net immunization services. This type of spatially relevant assessment is useful for public health programs to allocate attention to areas with the greatest need, especially for the introduction of new disease prevention strategies. These approaches can also be repeated for surveillance and planning purposes on a periodic basis within regions where smaller geographic areas may face varying public health needs. This type of spatial analysis is also beneficial to understanding demographic trends of inner cities and movement of underserved populations for health care delivery purposes and further supports the need for efficient use of large population-based data in cancer control assessments.

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## Acknowledgments

This analysis for the study was conducted under funding by the Jonsson Comprehensive Cancer Center Pre-doctoral Fellowship Grant and the UCLA NIH/NCI R25 Cancer Education and Career Development Program. Jennifer Tsui is currently funded by the NIH/NCI T32 Postdoctoral Research Fellowship program at Columbia University, which supported the completion and submission of this manuscript. We thank Myles Cockburn, PhD, for providing the Los Angeles Cancer Surveillance Program's geographic data. We also thank our colleagues at the Los Angeles County Department of Public Health's Sexually Transmitted Disease Program for providing Chlamydia data. We gratefully acknowledge Myles Cockburn, PhD, and Andrew Rundle, DrPH, for their feedback on this manuscript.

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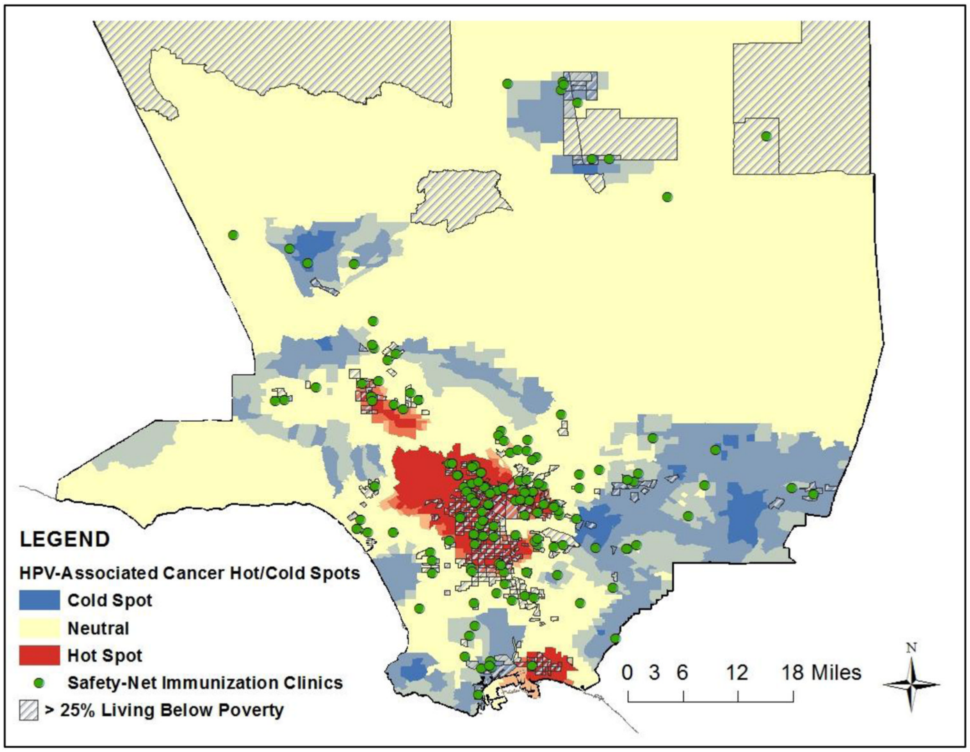


**Figure 1.**
Hot Spot Analysis of Chlamydia Rates in Los Angeles County

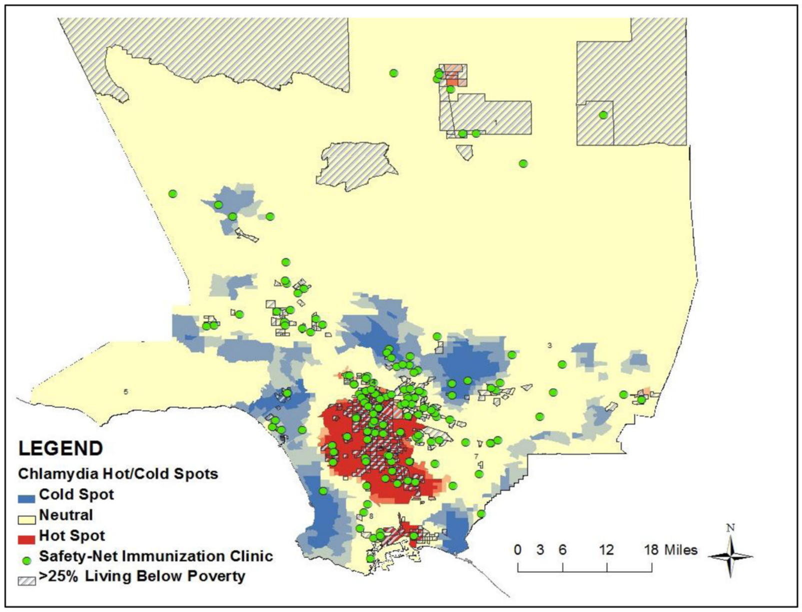


**Figure 2.**
Hot Spot Analysis of HPV-associated Cancer Rates in Los Angeles County

## Table 1

Neighborhood Characteristics by risk groups for HPV-associated cancer and Chlamydia incidence*

| Characteristics | HPV-associated Cancers | | | Chlamydia | | |
|---|---|---|---|---|---|---|
| | High n=536 | Medium n=912 | Low n=604 | High n=386 | Medium n=1488 | Low n=178 |
| | % (SD) | % (SD) | % (SD) | % (SD) | % (SD) | % (SD) |
| *Socio-demographic* | | | | | | |
| % Living below poverty | 24.8 (13.6) | 13.3 (10.1) | 10.5 (8.8) | 28.0 (13.2) | 12.8 (9.7) | 10.5 (11.1) |
| % Less than high school educ. | 36.4 (20.9) | 23.1 (18.2) | 21.4 (15.7) | 43.7 (16.6) | 23.3 (17.7) | 10.8 (10.3) |
| % No Vehicle | 19.0 (12.4) | 7.4 (6.2) | 5.0 (4.8) | 18.8 (13.0) | 7.8 (7.5) | 6.8 (6.4) |
| Race/ethnicity | | | | | | |
| % White | 44.5 (21.7) | 53.1 (22.2) | 53.8 (18.9) | 32.8 (16.4) | 54.6 (19.7) | 60.9 (23.5) |
| % African American | 13.3 (17.7) | 8.8 (14.9) | 4.5 (7.2) | 24.7 (0.23) | 5.3 (7.9) | 2.3 (4.3) |
| % Asian | 9.4 (12.4) | 12.8 (15.0) | 16.4 (17.7) | 4.7 (8.9) | 13.5 (14.5) | 26.5 (22.1) |
| % Latino | 55.6 (30.2) | 42.0 (29.9) | 44.6 (28.5) | 65.3 (25.3) | 45.1 (29.3) | 15.4 (10.0) |
| % Non-Citizen | 28.6 (14.5) | 17.9 (11.4) | 14.6 (9.7) | 29.3 (13.4) | 17.9 (12.0) | 14.2 (9.7) |
| % Linguistically Isolated | 8.1 (5.7) | 4.5 (3.5) | 3.5 (2.6) | 7.2 (5.4) | 4.6 (3.9) | 5.2 (4.6) |
| *5-year Incidence Rates*^ | | | | | | |
| HPV-associated cancers | 130 (450) | 50 (60) | 20 (20) | | | |
| Chlamydia | | | | 4100 (2700) | 1500 (800) | 700 (400) |
| *Geographic Access* | | | | | | |
| Distance to clinic (mean, SD) | 1.14 (0.93) | 1.92 (2.07) | 2.31 (1.45) | 0.88 (0.59) | 2.04 (1.86) | 2.10 (1.35) |

*Risk groups based on high, medium, low hot spots from Figures 1 and 2

^Rates presented in cases per 100,00

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**Table 2a**

Unadjusted and adjusted results for neighborhood distance to clinic (log-miles) and cancer hotspots

| | Unadjusted | Adjusted: Model 1 | Adjusted: Model 2 |
|---|---|---|---|
| | **Beta Coefficient (95% CI)** | **Beta Coefficient (95% CI)** | **Beta Coefficient (95% CI)** |
| Intercept | | 1.02 (1.02, 1.05) ** | 1.32 (1.28, 1.36) ** |
| Cancer hotspot | −0.40 (−0.45, −0.36) ** | 0.01 (−0.72, 0.75) | 0.03 (−0.01, 0.07) |
| % Living below poverty | −3.76 (−4.11, −3.40) ** | −0.61 (−0.83, −0.39) ** | −0.68 (−0.90, −0.46) * |
| % Less than hs education | −2.68 (−2.80, −2.48) ** | −1.77 (−1.88, −1.65) ** | 0.02 (−0.21, 0.25) |
| % No Vehicle | −4.69 (−5.12, −4.25) ** | −2.36 (−2.64, −2.07) ** | −1.28 (−1.58, −0.98) ** |
| % White | 1.53 (1.36, 1.69) ** | | |
| % African American | −0.54 (−0.75, −0.31) ** | | −0.75 (−0.86, −0.64) ** |
| % Asian | 0.49 (0.22, 0.75) ** | | −0.29 (−0.42, −0.16) * |
| % Latino | −1.54 (−1.65, −1.43) ** | | −0.84(−0.97, −0.71) ** |
| % Non-Citizen | −4.08 (−4.32, −3.84) ** | | −1.07(−1.36, −0.78) ** |
| % Linguistically Isolated | −10.5 (−11.3, −9.75) ** | | −2.96 (−3.70, −2.22) * |

** $p<0.001$,

* $p<0.05$

## Table 2b

Unadjusted and adjusted results for neighborhood distance to clinic (log-miles) and Chlamydia hotspots

| | Unadjusted | Adjusted: Model 1 | Adjusted: Model 2 |
|---|---|---|---|
| | **Beta Coefficient (95% CI)** | **Beta Coefficient (95% CI)** | **Beta Coefficient (95% CI)** |
| Intercept | | 1.03 (1.00, 1.06) ** | 1.33 (1.29, 1.37) ** |
| Chlamydia Hotspot | −0.72 (−0.81, −0.64) ** | 0.02 (−2.25, 7.24) | 0.07 (−0.67, 0.80) |
| % Living below poverty | −3.76 (−4.11, −3.40) ** | −0.62 (−8.51, −4.02) * | −0.64 (−0.86, −0.56) ** |
| % Less than hs education | −2.68 (−2.80, −2.48) ** | −1.76 (−1.89, −1.66) ** | −0.01 (−0.13, 0.11) |
| % No Vehicle | −4.69 (−5.12, −4.25) ** | −2.34 (−2.60, −2.08) ** | −1.29(−1.57, −1.01 ) ** |
| % White | 1.53 (1.36, 1.69) ** | | |
| % African American | −0.54 (−0.75, −0.31) ** | | −0.83 (−0.88, −0.78) ** |
| % Asian | 0.49 (0.22, 0.75) ** | | −0.29 (−0.51, −0.07) * |
| % Latino | −1.54 (−1.65, −1.43) ** | | −0.84 (−1.07, −0.61) ** |
| % Non-Citizen | −4.08 (−4.32, −3.84) ** | | −2.91 (−3.03, −2.79) * |
| % Linguistically Isolated | −10.5 (−11.3, −9.75) ** | | −2.11 (−3.64, −1.44) * |

** p<0.001,

* p<0.05