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Exploring the Roles of Geographic and Neighborhood Level Factors on HPV Vaccine Access and Uptake among Low-income Populations in Los Angeles County

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Exploring the Roles of Geographic and Neighborhood Level Factors on HPV Vaccine Access and Uptake among Low-income Populations in Los Angeles County

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Health Services

by

Jennifer Tsui

2012

ABSTRACT OF THE DISSERTATION

Exploring the Roles of Geographic and Neighborhood Level Factors on
HPV Vaccine Access and Uptake
among Low-income Populations in Los Angeles County

by

Jennifer Tsui
Doctor of Philosophy in Health Services
University of California, Los Angeles, 2012
Professor Roshan Bastani, Chair

Cervical cancer disproportionately affects minority, immigrant, and low-income women. Human Papillomavirus (HPV) vaccines have the potential to substantially prevent high risk HPV infections and future cases of cervical cancer. Recent studies show that HPV vaccine uptake in high risk groups remains low. Even with available programs that provide the vaccine for free to low-income populations, multiple barriers, including lack of geographic accessibility to safety-net immunization clinics, may prevent disadvantaged adolescent girls from obtaining the vaccine. Current disparities in cervical cancer will likely persist as a result of HPV vaccine under-utilization among disadvantaged populations.

This dissertation is comprised of three studies that explore the roles of geographic and neighborhood factors on HPV vaccine access and uptake among low-income, racial/ethnic

minority populations in Los Angeles County (LAC). Data collected from mothers of HPV vaccine age-eligible girls as well as secondary data from the U.S. Census Bureau, LAC Sexually Transmitted Diseases Program and LAC Cancer Surveillance Program were used in the analyses. Geographic information system mapping (GIS) techniques and multivariate logistic regression models for clustered data were employed.

This research found that HPV vaccination services via safety-net clinics are, in general, geographically accessible for low-income, high-risk populations in Los Angeles County. Some exceptions to the primary findings should be noted: (1) some racial/ethnic differences in proximity to clinics emerged and warrant further exploration, (2) a few specific neighborhoods with high cervical cancer risk may benefit from targeted improvements in geographic access to HPV vaccination services, and (3) particular attention should be paid to low-income girls living in moderately poor neighborhoods where geographic access to nearby safety-net services is limited. Increased proximity to safety-net clinics was not significantly associated with increased vaccine uptake. While vaccination rates were highest among low-income girls in neighborhoods with the greatest poverty and proportion of minority residents, these factors were not independently related to vaccination after controlling for individual factors. Mother's awareness of HPV, age of girl, and having public insurance were also significant predictors of uptake.

Findings suggest that low-income communities continue to need increased access to information about HPV. Results also suggest health care coverage, specifically underinsurance among low-income adolescents, and clinic-based operational factors are worth exploring in future research as barriers to HPV vaccination. Future research should continue to focus on individual, physician, and organizational strategies to increase vaccine uptake, especially in relation to high-risk populations that could benefit most from the HPV vaccine.

The dissertation of Jennifer Tsui is approved.

Gilbert Chee-Leung Gee

Hector P. Rodriguez

Gerald F. Kominski

Roshan Bastani, Committee Chair

University of California, Los Angeles

2012

For my grandparents,

Chieh Ching Lee and Wan Chung Lee.

My early experiences as their medical interpreter and navigator

fueled the work I do now and always.

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CHAPTER 1:

Introduction to the Dissertation

This dissertation is comprised of three studies that explore the roles of geographic and neighborhood factors on HPV vaccine access and uptake. The research focuses on low-income, racial/ethnic minority populations in Los Angeles County and aims to address the following: (1) whether there is an association between individual geographic access to safety-net immunization clinics and HPV vaccine initiation among low-income, minority girls, (2) whether neighborhood level poverty and proportion of minority residents are associated with HPV vaccine initiation among the same sample of low-income, minority girls, and (3) if neighborhoods with high cervical cancer risk have adequate geographic access to safety-net immunization services compared to neighborhoods with lower risk. This chapter provides an overview of cervical cancer disparities, emerging research about HPV vaccine uptake, and the influence of geographic and neighborhood factors on health care utilization. The chapter concludes by describing the conceptual framework used to guide this dissertation work and a brief description of each study.

1.1 Cervical Cancer Disparities and HPV Vaccination

Cervical cancer disproportionately affects minority, immigrant, and low-income women. The American Cancer Society estimates that 12,710 new cases and 4,220 deaths from cervical cancer will occur in the United States (U.S.) in 2012 (American Cancer Society, 2012). Research continues to show that incidence and mortality are unevenly distributed across socioeconomic status, racial/ethnic groups, and geography (Freeman, 2005; Krieger et al., 1999; McDougall et al., 2007; Saraiya et al., 2007; Yin et al., 2010). Despite the widespread adoption of Pap testing and the subsequent decrease in cervical cancer cases in the general population, disadvantaged

groups often face additional barriers to accessing screening services and thus have much higher rates of cervical cancer (Coughlin et al., 2008; Datta et al., 2006; Tsui et al., 2007). While many studies link low screening rates to individual factors such as health insurance coverage, socioeconomic status, English proficiency, and lack of awareness (Coughlin and Uhler, 2000; Freeman and Wingrove, 2005; Ponce et al., 2006), an increasing number of studies also recognize cervical cancer disparities to be markers of larger social inequalities rooted in the context of geographically-based characteristics (Datta et al., 2006; Krieger et al., 2002; McCarthy et al., 2010; Singh and Miller, 2004).

1.1.1 Cervical cancer disparities persist in Los Angeles County

In Los Angeles County, cervical cancer incidence is significantly higher than the national average (Liu et al., 2009; NCI, 2010; SEER, 2009) with Latinas and Asian/Pacific Islander women having the highest rates among all ethnic groups (Cockburn et al., 2009). These disparities are tied to the immense demographic and geographic diversity of the region. With over 10 million residents, Los Angeles County is the most populous county in the United States. The county spans an immense geographic area (over 4,000 square miles) that is nearly comparable to the state of Connecticut. For purposes of health care delivery and planning, the county is divided in eight Service Planning Areas (SPAs). Low-income, racial/ethnic minority and immigrant populations are concentrated in the county's urban center, primarily within SPAs 4 and 6 (Figure 1.1). Populations living within these areas experience poorer health outcomes and greater barriers to care (LACDPH, 2009). For example, over 30% of residents in SPAs 4 and 6 are uninsured compared to just 12% of those living in SPA 2 (LACDPH, 2009).

Women from more disadvantaged areas of Los Angeles County also have the lowest rates of cervical cancer screening (LACDPH, 2010). These areas are also associated with higher rates of HPV infection (Benard et al., 2008; Liu et al., 2009), earlier age of sexual initiation among adolescent girls, and lower education. Girls from these areas, thus, have a higher risk of cervical cancer and could greatly benefit from the HPV vaccine. The demographic diversity and existing health disparities of Los Angeles County, therefore, make this large urban environment an ideal setting to examine geographic and neighborhood level factors on access to and uptake of this new cervical cancer prevention method.

1.1.2 HPV Vaccine Indications and Guidelines

The recently available human papillomavirus (HPV) vaccines provide an additional opportunity for a new generation of adolescents to be protected from high risk HPV infection and cervical cancer (CDC, 2007). Currently, two HPV vaccines (quadrivalent and bivalent) introduced in 2006 and 2009 respectively, are available for routine use among adolescents and young women. Both vaccines prevent against the infection of two high risk HPV-types (16 and 18) responsible for over 70% of all cervical cancer cases worldwide (CDC, 2007; CDC, 2010). The quadrivalent vaccine also protects against two other HPV-types (6 and 11) that are associated with genital warts. In addition, HPV infections are linked to the development of other cancers, including vulvar, vaginal, anal, penile, and oropharyngeal sites (Benard et al., 2008), extending the potential benefit of the vaccines. It is estimated that 19% of adolescent girls in the U.S. are infected with HPV, making it the most common sexually transmitted infection in this age group (Forhan et al., 2009). Acquisition of HPV infection also occurs soon after sexual

initiation, even among those with few sexual partners (Forhan et al., 2009). This supports the need to administer the HPV vaccine to adolescent girls before the onset of any sexual activity.

Both vaccines are recommended by the Advisory Committee on Immunization Practices (ACIP) for routine use among girls ages 11 to12 years old and catch-up vaccination for girls and young women ages 13 to 26 years old (CDC, 2007; CDC, 2010). The quadrivalent vaccine was also recently recommended for routine use among boys ages 11 to12 years old based on its added protection against HPV types associated with genital warts (CDC, 2011).

1.1.3 Vaccines for Children Program and Safety-net Immunization Services

Following ACIP recommendations, the Vaccines for Children (VFC) program included HPV vaccines in the nationally subsidized immunization program for underserved adolescents (CDC, 2011). The federally funded VFC program covers the cost of vaccines to eligible low-income children (i.e. 0-18 years of age, Medicaid enrollees, uninsured, or American Indian/Alaskan Native) (CDC, 2011). In Los Angeles County, free or low-cost HPV vaccines through the VFC program can be accessed through county affiliated safety-net clinics, either those operated by the Los Angeles County Department of Health Services or non-profit private-partnership clinics. In addition, some clinics also receive federal funding from Section 317 to subsidize vaccination costs for underinsured children in the county (Centers for Disease Control and Prevention, 2010). The Los Angeles County Department of Public Health's Immunization Program routinely directs low-income families to a list of affiliated VFC provider clinics for safety-net immunization services. While safety-net clinics are traditionally located in underserved low-income areas, little is known about whether these safety-net immunization services are accessible to communities at high risk for cervical cancer

1.1.4 Low adoption of HPV vaccines

Currently, adolescent HPV vaccination rates remain low. Recent national data revealed only 49% of adolescent girls in the U.S. initiated the HPV vaccine and 32% completed the 3-dose series in 2011 (CDC, 2011). These rates are much lower than uptake rates for other newly introduced adolescent vaccines and far from the 80% HPV vaccine completion goal set for Healthy People 2020 (U.S. Department of Health and Human Services, 2012). Unless the vaccine is adopted by all subgroups, including girls that are most at risk for cervical cancer, disparities will likely remain. Some studies indicate that racial/ethnic disparities for other cancer types persisted or even increased due to the inequitable adoption of increasingly available effective medical interventions for treatment or early detection (Tehranifar et al., 2009). While HPV vaccines can have the largest impact and be most cost-effective in populations that do not receive routine screening (Kim and Goldie, 2008), few studies have focused on barriers to HPV vaccine uptake in disadvantaged populations. Even with available programs that subsidize vaccine costs for low-income populations, barriers aside from cost may prevent disadvantaged girls from obtaining the HPV vaccine.

Existing research on predictors of HPV vaccination has focused mainly on individual level factors, such as vaccine knowledge (Bastani et al, 2011; Brabin et al., 2006; Gerend et al., 2009; Tiro et al., 2007) and acceptability (Brewer and Fazekas, 2007; Constantine and Jerman, 2007; Dempsey et al., 2006; Scarinci et al., 2007). The growing body of research in this area suggests disparities in HPV vaccine knowledge and awareness mirrors disparities in other cancer prevention areas. This is illustrated in a recent study on HPV vaccine awareness among parents which showed that less educated and racial/ethnic minority parents were less likely to have heard of the HPV vaccines (Hughes et al., 2009). At the same time, other studies indicate HPV vaccine

acceptability is high once parents are aware of the vaccine (Rosenthal et al., 2008; Scarinci et al., 2007) and, therefore, low vaccination rates may be due to structural barriers rather than attitudes about the vaccine.

Recent studies focusing on HPV vaccine uptake also provide limited information on diverse low-income populations (Brewer and Fazekas, 2007; Chao et al., 2010; Gerend et al., 2009; Lau et al., 2012; Pruitt and Schootman, 2010; Reiter et al., 2009; Reiter et al., 2010; Rosenthal et al., 2008; Tiro et al., 2011; Tiro et al., 2012; Yeganeh et al., 2010). These studies indicate income, insurance status, provider recommendation, and having a usual source of care are emerging predictors of HPV vaccination. Two recent studies have explored individual psychosocial and demographic factors associated with HPV vaccination among adolescents from high-risk communities in Los Angeles County (Bastani et al., 2011; Guerry et al., 2011). Both studies showed low vaccination rates and revealed that awareness of the vaccine (Bastani et al., 2011) as well as having a provider recommendation (Guerry et al., 2011) were important in predicting uptake. Both studies also showed that parents of unvaccinated girls needed more information about the HPV vaccine in order to make a decision about vaccinating their daughters. Neither study examined whether these high-risk communities were within an accessible distance to safety-net immunization services. Few studies have explored geographic access to clinics neighborhood level factors, especially among disadvantaged girls, as potential influencers of individual HPV vaccine initiation.

1.2 Geographic Access to Care

Limited geographic access to safety-net clinics where free vaccinations services are available is one potential barrier to HPV vaccine uptake for disadvantaged populations that may

partially explain low vaccination rates among these groups. However, geographic access to HPV vaccines has received little attention in the research literature. Geographic access to care, defined by Penchansky and Thomas (Penchansky and Thomas, 1981) as the relationship between the location of health services and the location of patients (i.e. travel time, distance), has been shown to impact the utilization of other health services, including HIV testing, asthma management, breast cancer screening, and childhood immunizations (Allard et al., 2003; Fu et al., 2009; Huang et al., 2009; McLafferty, 2003; Teach et al., 2006). For example, 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 (Fu et al., 2009). In a similar study, asthmatic children with increased proximity to providers had better longitudinal asthma management (Teach et al., 2006). This growing body of research indicates geographic barriers to care may be an important factor to consider when examining access of health services.

Given the understanding that access to care is often more limited among low-income, minority and limited English speaking communities (Smedley et al., 2003), geographic access to safety-net immunization clinics may be one explanation for low HPV vaccine initiation rates in underserved populations. In relation to cancer prevention, studies have confirmed that travel distance and travel time to cancer treatment or screening facilities differ by socioeconomic status and race/ethnicity (Huang et al., 2009; Mobley et al., 2008). Potentially unequal geographic distributions of safety-net immunization clinics across immigrant and ethnic enclaves may cause geographic access to clinics to differ by race/ethnicity (Logan et al., 2002; Zenk et al., 2006). A study by Zenk and colleagues found mammography services to be further away from low-income African American neighborhoods compared to low-income non-Hispanic white neighborhoods (Zenk et al., 2006). Other studies have also found that the relationships between

travel distance and travel time on use of health services to differ by race/ethnicity. For example, a study by Koizumi and colleagues found some racial/ethnic groups to be less likely to travel further for mental health services compared to other groups (Koizumi et al., 2009). At the same time, other literature suggests that some groups rely on services within their own ethnic community due linguistic and cultural barriers (Gany et al., 2006; Mobley et al., 2008; Ngo-Metzger et al., 2007; Yang and Kagawa-Singer, 2007). No studies so far have investigated whether geographic access may be associated with HPV vaccine initiation or whether the relationship between geographic access and HPV vaccine initiation differs by race/ethnicity. Although HPV vaccines are available for free or low cost to low-income girls at existing safety-net immunization clinics, it is also unclear whether these clinics are geographically accessible to all communities at high-risk for cervical cancer.

1.3 Neighborhood Factors and Health Care Utilization

Despite the fact that disadvantaged neighborhoods experience a disproportionate cervical cancer burden, there is a limited understanding of whether neighborhood socio-demographic factors, in addition to geographic access, might influence HPV vaccination behavior, (Krieger et al., 1999; Lim and Ashing-Giwa, 2011; Yin et al., 2010). Contextual characteristics of neighborhoods have been shown to significantly influence individual health outcomes (Acevedo-Garcia, 2000; Borrell et al., 2004; Diez Roux, 2001; Kawachi and Berkman, 2003; Lynch et al., 1998; Malmstrom et al., 1999; Subramanian et al., 2005; Williams and Collins, 2001; Winkleby et al., 2006), health behaviors (Gordon-Larsen et al., 2006; Lovasi et al., 2008) and health care utilization (Coughlin et al., 2008; Lian et al., 2008; Mobley et al., 2008; Schootman et al., 2006). Prior studies have examined the influence of neighborhood characteristics on individual health

status and health behaviors through a variety of pathways related to residential segregation, community level exposure to disease, availability of health care resources, and social capital (Acevedo-Garcia, 2000; Achat et al., 1998; Borrell et al., 2004; Browning et al., 2003; Kawachi and Berkman, 2003; Kirby and Kaneda, 2005; Mobley et al., 2008; Williams and Collins, 2001). Neighborhood socioeconomic disadvantage has specifically been associated with lower uptake of preventive health services, including cancer screening (Coughlin et al., 2008; Datta et al., 2006; Lian et al., 2008; Schootman et al., 2006), even after controlling for individual socioeconomic status. Poorer neighborhoods are often also enclaves for a greater proportion of minority residents. Members of these communities face additional barriers to care, including limited English proficiency (Ngo-Metzger et al., 2007; Ponce et al., 2006; Yang and Kagawa-Singer, 2007), further distance from services (Cordasco et al., 2010), lack of culturally competent care, limited financial resources and discrimination in the health care system (Gee, 2008; Williams and Collins, 2001) that hinder the uptake of prevention services. On the contrary, neighborhoods with a significant proportion of members from the same racial/ethnic community may in turn experience positive influences, including increased access to information (Rogers, 2003) and social support (Kawachi and Berkman, 2000; Mobley et al., 2008), that aid in increasing access to and uptake of preventive care services.

To date, only a few studies have assessed the impact of neighborhood level characteristics on HPV vaccination (Chao et al., 2010; Pruitt and Schootman, 2010) and no neighborhood level studies have focused on disadvantaged populations. These recent studies focusing on neighborhood factors and HPV vaccination demonstrated conflicting results. Chao and colleagues found that girls living in poorer neighborhoods were less likely to initiate the vaccine (Chao et al., 2010; Pruitt and Schootman, 2010) while Pruitt and Schootman showed

girls living in poorer counties to be more likely to initiate the vaccine (Pruitt and Schootman, 2010). Given the growing literature that points to neighborhood context as a determinant in health outcomes and health care use, it is important to examine whether neighborhood factors influence HPV vaccine initiation.

1.4 Dissertation Aims & Hypotheses

This dissertation employed a social ecological perspective to address the following question: How do geographic and neighborhood level factors impact HPV vaccine access and uptake among low-income populations in Los Angeles County? The dissertation is comprised of three distinct studies that explore the previously unexamined roles of geographic and neighborhood level factors on HPV vaccination. Multiple datasets, including individual level data collected from the Los Angeles County Department of Public Health's Office of Women's Health and neighborhood level data from the U.S. Census Bureau and the Los Angeles County Department of Public Health were used to address the primary research question and study aims.

1.4.1 Conceptual Framework

A primary concept of the social ecological perspective is that multiple levels of influence, including interpersonal, community, institutional and policy levels, affect individual health behavior (Brofenbrenner, 1979; Glanz et. al., 2005; McLeroy et. al., 1988; Stokols, 1996). This dissertation used the social ecological perspective to understand the relative contributions of geographic access, neighborhood factors, and individual level factors on HPV vaccine initiation.

A conceptual framework depicting the primary relationships assessed in this dissertation is shown in Figure 1.2. Study 1 examined if individual spatial access to care is associated with

individual HPV vaccine initiation, after controlling for individual level risk factors. Study 1 also examined if individual race/ethnicity moderates the relationship between individual spatial access and individual HPV vaccine initiation. Study 2 explored whether neighborhood level risk factors are associated to individual HPV vaccine initiation, after controlling for individual risk factors. Study 3 assessed whether neighborhood level cervical cancer risk is associated with neighborhood level geographic access to safety-net immunization clinics.

As displayed in the framework (Figure 1.2) and supported in the literature, neighborhood and individual level risk factors are associated with each other and both predict individual HPV vaccine initiation. Individual level factors include daughter's race/ethnicity, age, usual source of care, mother's demographic characteristics (age, education, nativity), and mother's HPV awareness. Neighborhood level risk factors include socio-demographic characteristics (proportion of minority residents, proportion living below poverty level) and cervical cancer risk (incidence rates of Chlamydia, incidence rates of HPV-related cancers) at the census tract level.

In this dissertation, geographic access was conceptualized as one possible pathway between individual and neighborhood factors and HPV vaccination behavior. Proximity to immunization clinics is a construct that links individual residence or neighborhoods with geographic locations of safety-net immunization clinics. Individual geographic access to clinics was hypothesized to directly influence individual HPV vaccine initiation, with increased access (shorter travel distance and travel time to the nearest clinic) leading to higher rates of individual HPV vaccine initiation. In addition, neighborhood level factors, including cervical cancer risk, was conceptualized to be associated neighborhood geographic access to safety-net immunization clinics. Increased neighborhood cervical cancer risk was hypothesized to be associated with

increased neighborhood geographic access to safety-net clinics because safety-net clinics are specifically funded to deliver care to underserved communities (Saviano and Powers, 2005).

Racial/ethnic groups may differ in their response to geographic access as a barrier to health care services (Buchmueller et al., 2006; Clarke et al., 2007). For example, proximity to services may have less impact on HPV vaccine initiation in groups that are generally willing and able to travel further to receive health care compared to other racial/ethnic groups that are not as willing or able to travel further for care (Koizumi et al., 2009; Silver et al., 2010). Chinese and Korean populations, for example, may be willing to travel further to obtain care from organizations that are culturally and linguistically concordant. Therefore, individual race/ethnicity was hypothesized to be associated with individual HPV vaccination and modify the relationship between spatial access and individual HPV vaccination. The following section provides a brief summary of the purpose and hypotheses of each study in the dissertation.

1.4.2 Individual Geographic Access to Clinics and HPV Vaccine Initiation (Study 1)

The first study examined whether geographic access to safety-net clinics is associated with HPV vaccine initiation among low-income, minority girls. It was hypothesized that low-income minority girls with increased geographic access to the nearest safety-net immunization clinic are more likely to initiate the HPV vaccine (receive ≥ 1 dose) compared to girls who lower geographic access, after controlling for individual and mother's characteristics. The study also hypothesized that the relationship between geographic access and HPV vaccination differs by race/ethnicity, with geographic access having a larger effect for Korean and Chinese girls compared to Latina girls. This hypothesized interaction effect was based on prior literature showing preferences for some groups (i.e. Chinese, Korean) to seek health care from culturally

targeted agencies within ethnic communities even if individuals live outside of these ethnic centers (Ngo-Metzger et al., 2007; Traylor et al., 2010). The study used primary individual level data collected from mothers of HPV vaccine age-eligible girls (ages 9 - 18 years) who routinely access the county safety-net system as well as locations of county affiliated safety-net clinics that provided free immunization services to adolescents.

1.4.3 Neighborhood Socio-demographic Factors and HPV Vaccine Initiation (Study 2)

The second study assessed whether neighborhood level socio-demographic characteristics (i.e. contextual poverty rates and racial/ethnic composition) are associated with HPV vaccine initiation among the same sample of low-income, minority girls used in first study. It was hypothesized that low-income minority girls living in neighborhoods with higher poverty rates and greater proportions of ethnic minority households have lower rates of HPV vaccine initiation, even after controlling for individual level characteristics. It was also recognized that, while the literature provides support for this primary hypothesis, an opposing hypothesis that low-income girls in disadvantaged neighborhoods could have higher rates of HPV vaccine initiation due to the concentration of safety-net services in these areas was also probable. The individual level data from the first study was linked at the census tract level to neighborhood socio-demographic data from the 2005-2009 American Community Survey data.

1.4.4 Neighborhood Cervical Cancer Risk and Geographic Access to Clinics (Study 3)

The last study explored whether neighborhood level cervical cancer risk was associated with neighborhood level geographic access to HPV vaccines via safety-net immunization clinics. This study examined cervical cancer risk using rates of Chlamydia and HPV-related cancers for

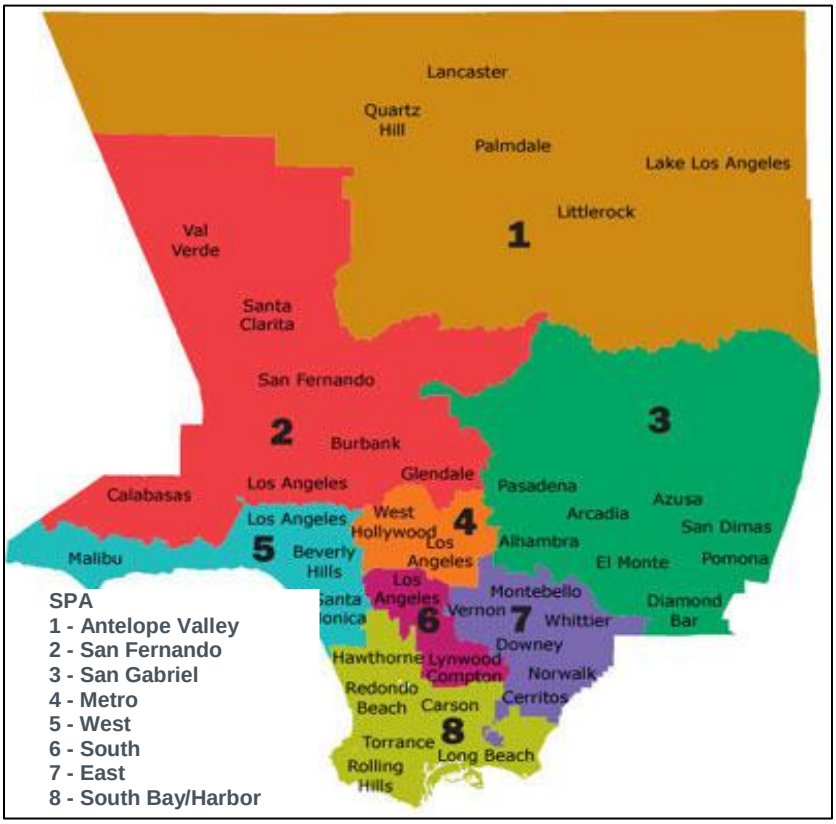
all census tracts in Los Angeles County using data from the county's STD program and cancer registry. The purpose of this third study was also to identify whether neighborhoods with the greatest risk/need had geographic access to HPV vaccination services. It was hypothesized that neighborhoods with high cervical cancer risk would have greater geographic access to safety-net immunization clinics compared to neighborhoods with low risk because high risk neighborhoods are often also poorer areas targeted for safety-net services. The study also focused on exploring the characteristics of high-risk neighborhood where there was limited geographic access to determine where polices or programs can be implemented to improve cervical cancer prevention for underserved populations.

1.5 Innovation and Contributions of Dissertation Research

The current literature indicates geographic and neighborhood factors can play significant roles in HPV vaccine access and uptake. Few studies, however, have examined whether these factors influence HPV vaccination in underserved populations and whether neighborhoods with high cervical cancer risk have access to the HPV vaccines through safety-net immunization clinics. Therefore, this dissertation research is unique in several ways that will contribute to our current understanding of cervical cancer prevention and control. First, the research focused on low-income, minority communities in one of the largest urban areas of the nation. Second, the research is unique to the HPV literature in moving beyond individual level factors to assess the impact of geographic and neighborhood factors on HPV vaccine initiation. Few studies have focused on these factors among disadvantaged populations. Lastly, the dissertation employed several novel approaches to improve our understanding of health care disparities and provided a useful lens to identify safety-net vaccination services for high-risk communities within the

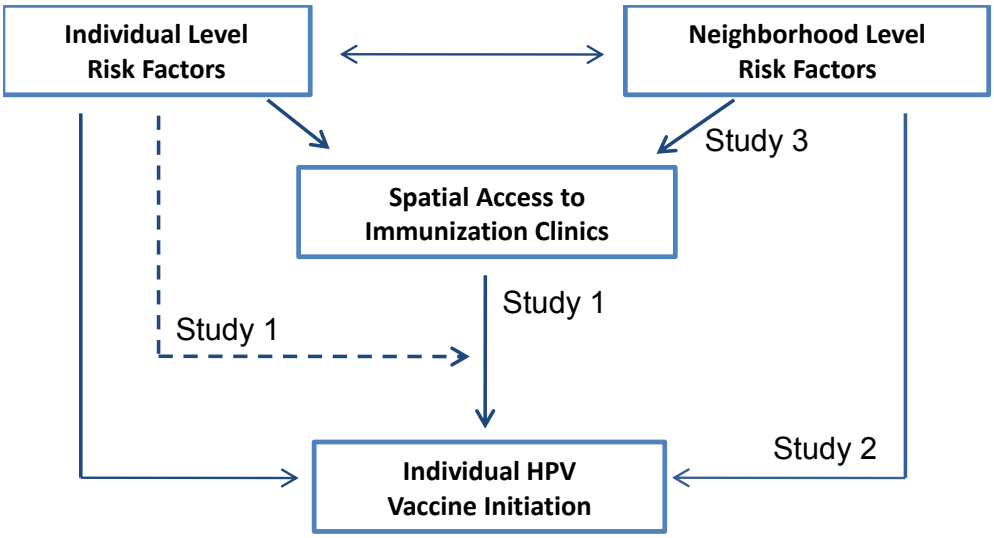
context geography. The results of this research, therefore, can directly inform future cancer control programs and policies as well as improve the current understanding an emerging health care disparity.

Figure 1.1 Los Angeles County Service Planning Areas



Source: Los Angeles County Department of Public Health, Community Health Services webpage. Accessed on March 15, 2012. http://publichealth.lacounty.gov/chs/SPAMain/ServicePlanningAreas.htm

Figure 1.2 Conceptual Framework



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CHAPTER 2:

Geographic access to safety-net clinics and HPV vaccine initiation among low-income, ethnic minority girls (Study 1)

2.1 Abstract

Purpose: Human Papillomavirus (HPV) vaccine uptake remains low. Although publicly funded programs provide free vaccines to low-income children, barriers aside from cost may prevent disadvantaged girls from obtaining the HPV vaccine. This study examines whether HPV vaccines are geographically accessible via safety-net clinics and whether proximity to clinics is associated with vaccine initiation among low-income girls in Los Angeles County.

Methods: Interviews were conducted in multiple languages with largely immigrant, low-income mothers of girls ages 9 to 18 via a county health hotline. Addresses of respondents and safety-net clinics were geo-coded and linked to create measures of geographic proximity. Logistic regression models were estimated for each proximity measure on HPV vaccine initiation while controlling for other factors.

Results: On average, 83% of the 479 girls had at least one clinic within 3-miles of their residence. Average travel distance (2.65 miles), public transportation time (21 minutes) and other proximity measures differed significantly by race/ethnicity. The overall HPV vaccine initiation rate was 28%. Increased proximity to the nearest clinic was not significantly associated with initiation. By contrast, daughter's age (OR 1.16, 95% CI: 1.06-1.26) and mother's awareness of HPV (OR 10.69, 95% CI: 2.39-20.81) were significantly associated with increased uptake.

Conclusions: In our study within a large urban environment, HPV vaccines were geographically accessible to the majority of low-income girls. Promoting awareness of the vaccine is likely more important than improving geographic access to vaccine initiation among this high-risk population. Future research should investigate other access-related factors that influence uptake.

2.2 Introduction

Low income, ethnic minority, and immigrant women experience a higher burden of cervical cancer in the United States (Freeman, 2005; Yin et al., 2010). The American Cancer Society estimates that 12,710 new cases and 4,220 deaths from cervical cancer will occur in the United States (Smedley et al.) in 2012 (American Cancer Society, 2012). While overall incidence (8.7 per 100,000) and mortality (3.6 per 100,000) rates are relatively low, the burden of cancer continues to be unevenly distributed across socioeconomic status, racial/ethnic groups, and geography (Freeman, 2005; Krieger et al., 1999; McDougall et al., 2007; Saraiya et al., 2007; Yin et al., 2010).

In Los Angeles County (LAC), cervical cancer incidence is significantly higher than the national average (12.1 per 100,000 vs. 8.1 per 100,000) (Liu et al., 2009; NCI, 2010; SEER, 2009) with Latina women having the highest rates (18.1 per 100,000) among all racial/ethnic groups (Cockburn et al., 2009). These disparities largely overlap with the most underserved communities in the county. Since disadvantaged areas are also associated with higher rates of HPV infection (Benard et al., 2008; Liu et al., 2009), earlier age of sexual initiation among adolescent girls, and lower education, girls from these communities have higher risk of developing cervical cancer and therefore could greatly benefit from access to HPV vaccines.

Wide-spread adoption of HPV vaccines has the potential to substantially prevent future cases of cervical cancer (CDC, 2007), especially in populations with increased burden of the disease (Kim and Goldie, 2008). The currently available HPV vaccines prevent infection of two high risk HPV-types (16 and 18) responsible for over 70% of all cervical cancer cases worldwide (CDC, 2007). The vaccines have been approved for use by girls and young women ages 9 to 26 years old and are recommended by the Advisory Committee on Immunization Practices for

routine use among girls ages 11 to12 years old (CDC, 2010). The quadrivalent vaccine, which additionally protects against genital warts, was also recently recommended for routine use among boys ages 11 to12 years old (CDC, 2011). HPV vaccines are included in the federally funded Vaccines for Children (VFC) program for low-income children who qualify (i.e. 0-18 years of age, Medicaid enrollees, uninsured, or American Indian/Alaskan Native) (CDC, 2010). In Los Angeles County, all county operated and affiliated safety-net immunization clinics provide free or low cost vaccines through the VFC Program to those who qualify.

Existing research on HPV vaccine uptake has focused mainly on individual level factors, including demographic characteristics, vaccine knowledge (Gerend and Magloire, 2008; Tiro et al., 2007) and acceptability (Brewer and Fazekas, 2007; Constantine and Jerman, 2007; Dempsey et al., 2009; Dempsey et al., 2006; Rosenthal et al., 2008). While a few recent studies (Guerry et al., 2011; Reiter et al., 2009) have explored HPV vaccination correlates among low-income and minority populations, the majority of HPV vaccination studies provide limited information on disadvantaged groups, especially in relation to Latino and Asian populations. The research to date suggests HPV vaccine knowledge and awareness mirror disparities seen in other cancer prevention areas, with less educated, low-income and ethnic minority parents being less likely to be aware of the HPV vaccines or have vaccinated daughters (Cates et al., 2009; Hughes et al., 2009; Reiter et al., 2011). However, less is known about whether aspects aside from individual level factors, such as accessibility of services and other health system factors, serve as potential barriers to HPV vaccination, especially among disadvantaged girls.

Geographic access to care, defined by Penchansky and Thomas (Penchansky and Thomas, 1981) as the relationship between the location of health services and the location of patients (i.e. travel time, distance), has been shown to impact utilization of other health services,

including HIV testing, asthma management, breast cancer screening, and childhood immunizations (Allard et al., 2003; Elkin et al., 2010; Fu et al., 2009; Leibowitz and Taylor, 2007; McLafferty, 2003; Meersman et al., 2009; Taylor et al., 2006; Teach et al., 2006). Importantly, a recent study found that low-income, urban children living closer to pediatricians were more likely to be up to date with childhood vaccinations (Fu et al., 2009). In a similar study, asthmatic children with increased geographic access (i.e. proximity) to providers had better longitudinal asthma management (Teach et al., 2006). In relation to cancer prevention, studies have confirmed that travel distance and travel time to cancer treatment or screening facilities differ by socioeconomic and race/ethnicity (Huang et al., 2009; Onega et al., 2008). This growing body of evidence suggests geographic barriers to care may have a substantial influence on the use of preventive services and thus may be a plausible barrier to HPV vaccine initiation for low-income groups. Few studies to date, have investigated whether geographic accessibility to vaccination services may be associated with uptake or whether geographic access to HPV vaccine differs by race/ethnicity.

This study examined whether HPV vaccines are geographically accessible via county-affiliated safety-net immunization clinics for low-income, ethnic minority girls in Los Angeles County. The study also assessed the extent to which HPV vaccine uptake is associated with proximity to safety-net immunization clinics. We hypothesized that increased proximity to safety-net immunization clinics is related to increased report of HPV vaccination among low-income minority girls. In order to assess whether geographic access is equally important across racial and ethnic subgroups, we examined the relationship between geographic access and initiation by race/ethnicity.

2.3 Materials and Methods

2.3.1 Individual Level Survey Data

This study used data from a survey of low-income caregivers of adolescent girls eligible for the HPV vaccine (ages 9 - 18 years). Study participants were recruited from the Los Angeles County Department of Public Health (LACDPH) Office of Women's Health (OWH) telephone hotline. Participants completed interviews between January and November 2009. The OWH multi-language toll-free hotline provides services, such as scheduling of cervical and breast cancer screening appointments and providing health information, to low-income (<200% federal poverty level) and uninsured women. Callers of the hotline are women who routinely use the LAC safety-net system.

Recruitment strategies, participant eligibility, major study findings and more detail about the OWH hotline were previously reported (Bastani et al.). Briefly, eligibility criteria included any female caller between 18 and 65 years and the medical decision-maker for at least one HPV vaccine eligible girl (9-18 years) in the household. Among eligible callers (n= 527 or 24.7% of women screened), 93% (n=490) provided informed consent to answer a survey, representing nearly all OWH hotline callers who make medical decisions for at least one adolescent girl. Since 85% of women in this larger study were mothers, rather than grandmothers, aunts, or sisters, study participants are referred to as "mothers" for simplicity. Mothers (n=490) were administered a 75-item telephone survey to assess their daughters' HPV vaccine uptake and correlates of uptake and mailed a $10 grocery card incentive for participating. A unique feature of this data is that it contains not only measures of HPV vaccination history, HPV awareness, and demographic data, but also home addresses, allowing participants to be geocoded and linked

to data at multiple levels (described below). This study was approved by the UCLA Institutional Review Board.

2.3.2 Measures

HPV vaccine initiation

HPV vaccine initiation was defined as a dichotomous (yes/no) outcome for whether an adolescent girl received at least one dose of the HPV vaccine as reported by mothers. At the time of data collection only the quadrivalent vaccine was approved for use among girls and young women so mothers were only asked about the quadrivalent vaccine. During the interview, mothers were asked about their awareness of HPV as well as the HPV vaccine. Mothers who were aware of the vaccine (61% of total sample) were then asked about their daughter's HPV vaccination history (i.e. whether daughter received any doses, how many doses). Mothers who reported their daughters did not receive any doses of the HPV vaccine as well as those mothers who reported no HPV vaccine awareness were categorized into the "uninitiated" group. Conversely, girls with mothers who reported they had received at least one dose of the vaccine were categorized into the "initiated" group. A few mothers (n=11) that reported their daughters initiated the vaccine also reported that they were unaware of HPV. Girls in this category were still classified as part of the "initiated" group.

Individual level covariates

Other independent variables included demographic characteristics of the mother (age, race/ethnicity, education, nativity), interview language, age of the adolescent girl, whether the adolescent girl has a usual source of care, and insurance type of the adolescent girl.

Race/ethnicity was measured by the following mutually exclusive categories: Latina, Chinese,

Korean, African American, and other race from the individual level survey data. The "other" race category included a small number of non-Latina whites (n < 10) and individuals from other Asian subpopulations (Filipinos, Vietnamese). Since the hotline targets low-income women with an annual household income of less than 200% federal poverty level, there was limited variability in family income across the study sample and therefore excluded as a covariate in the analysis. For daughter's age, we used the Advisory Committee on Immunization Practice's recommendations for HPV vaccination to transform the continuous age of adolescent girls to a categorical variable (9-10 years – pre-recommendation age group, 11-18 years – recommended age group) (CDC, 2007).

Geographic Access

Geographic access was operationalized as proximity to vaccination clinics. Our analyses included all clinics (n=155) affiliated with the Los Angeles County Immunization Program (LACDPH) that provided free or low cost vaccines through the Vaccines for Children (VFC) program in 2009 (LACDPH, 2010). For low-income girls in LAC, safety-net clinics serve as major points of access to primary care services, including receiving immunizations. These safety-net clinics include a combination of county operated health centers or immunization clinics, federally qualified health centers, public–private partnership clinics, and other free clinics that were identified by the LACDPH Immunization Program. Geographic data (addresses) for clinics were obtained through the LACDPH website and confirmed with the LACDPH Immunization Program staff.

We consider the barriers to access as defined by spatial and temporal "proximity." Physical distance can be an impediment to use, but so can the actual time it take to go from home

to a clinic (regardless of the actual distance). Hence, we used the following measures for geographic access:

1.) shortest straight-line (Euclidean) distance

2.) shortest travel distance over a road network

3.) availability of at least one clinic within a 3-mile geographical radius of residence

4.) shortest driving time

5.) shortest public transportation time

Similar measures of geographic access have been used in other studies examining access to care and geographic relationships to health services (Fu et al., 2009; Jones et al., 2009; Nykiforuk and Flaman, 2009; Sharkey et al., 2009). While recent studies have suggested that some measures (i.e. Euclidean distance versus travel distance) are equally suited in predicting geographic access (Jones et al., 2009), limited consensus exists within the literature as to which type of measure best captures geographic access in dense urban environments or for low-income populations (Guagliardo, 2004). In this study we explored using a variety of measures to characterize geographic access, however, travel distance over a road network and public transportation time are most relevant to low-income, ethnic minority populations in the Los Angeles area (Blumenberg and Smart, 2009).

2.3.3 Geographic Analysis

Geographic access measures were constructed by linking the geo-coded addresses of adolescent girls and locations of LAC safety-net immunization clinics. Residential addresses of respondents and safety-net immunization clinics were geo-coded using ArcGIS 10 (ESRI,

Redlands, CA). We excluded 11 participants with addresses that could not be geo-coded with 80% accuracy, leaving an analysis sample of 479 participants.

Straight-line distance was measured as the shortest direct distance (miles) between each respondent's residence and the nearest safety-net immunization clinic. Shortest travel distance was measured as the distance (miles) over the Los Angeles County road network between the respondent's residence and the location of the nearest safety-net immunization clinic. Straight-line distance is commonly used in studies, but fails to consider the realities of travel, where it is very unlikely that someone will have an uninterrupted path between their home and their destination. To account for this limitation, we also consider travel distance which incorporates additional lengths for turns, one-way streets, and general road layout. Both distances were calculated using ESRI's Network Analyst in ArcGIS10.

Coverage was defined as a dichotomous (yes/no) variable of whether at least one available immunization clinic exists within a 3-mile radius of each respondent's residence. Several prior studies have suggested average distance to health care facilities in urban areas is between 2 to 5 miles (Cordasco et al., 2010; Fu et al., 2009; Teach et al., 2006). This study starts with a 3-mile buffer for the coverage measure but also examined 1-mile and 2-mile buffers as a sensitivity analysis. Coverage measures were obtained using the buffer, overlay, and spatial join tools in ArcGIS10.

Shortest driving time and public transportation time was calculated in minutes for the travel time between each respondent's residence and the nearest immunization clinic. All clinics locations were transferred to Google Earth. Travel times were then calculated using the driving direction and public transportation functions in Google Maps. All times were calculated for

travel on Thursday afternoons at 4 pm for consistency and with the assumptions that most schools close between 2-3 pm and many clinics close by 5 pm.

2.3.4 Statistical Analysis

Initial descriptive statistics were conducted to describe the study sample and to examine the distributions of the primary outcome and predictor variables. Independent variables were assessed for multicollinearity (e.g. race/ethnicity and interview language) as well as the need for transformations, such as log-transforming or categorizing continuous variables. Bivariate associations between geographic access and race/ethnicity were tested using one-way ANOVA tests (distances and travel times) and Fisher's exact test (dichotomous coverage measure). Differences in geographic access by vaccine initiation were tested using Wilcoxon-Mann-Whitney tests (distances and travel times).

Logistic regression models were used to estimate the association between geographic access and HPV vaccine initiation while controlling for other factors:

$$\text{Logit}\,[\pi(Y)] = \beta_0 + \beta_1(X_1 = \textit{distance}) + \ldots + \beta_x X_x$$

This model was repeated for each geographic access measure. The African American (n= 38) and "other" race (n=30) categories were omitted from the multivariate analysis because of small numbers and limitations associated with interpreting results for a heterogeneous "other" race group.

As a sensitivity analysis, we explored the interaction effects between geographic access and race/ethnicity (Appendix 2.1):

$$\text{Logit}\,[\pi(Y)] = \beta_0 + \beta_1(X_1 = \textit{distance}) + \beta_2(X_2 = \textit{Chinese}) + \beta_3(X_3 = \textit{Korean}) + \ldots$$

$$+ \beta_x X_x \beta_7(X_7 = \textit{distance x Chinese}) + \beta_8(X_8 = \textit{distance x Korean})$$

Due to the strong association between mothers awareness of HPV and HPV vaccine initiation, a multinomial logistic regression model was also estimated using a three-level HPV vaccine initiation variable as an exploratory sub-analysis. This model (Appendix 2.2) compared *Initiated the HPV vaccine* and *Heard of HPV/No Initiation* with the base outcome of *Has not heard of HPV/No Initiation*:

$$\text{Logit}\,[\pi(\textit{Initiated the HPV vaccine}\,|\,\textit{Has not heard of HPV/No Initiation})] = \beta_0 + \beta_1(X_1 = \textit{distance}) + \ldots + \beta_x X_x$$

$$\text{Logit}\,[\pi(\textit{Heard of HPV/No Initiation}\,|\,\textit{Has not heard of HPV/No Initiation})] = \beta_0 + \beta_1(X_1 = \textit{distance}) + \ldots + \beta_x X_x$$

Statistical significance for all analyses was determined at the $p<0.05$ level. All multivariate regression results were obtained as odds ratios with 95% confidence intervals. All analyses were conducted using STATA 10 statistical software (Statacorp, College Station, Texas).

2.4 Results

2.4.1 Sample Characteristics

Over half (53.1%) of mothers in the sample (n=479) were Latina and close to a third (32.1%) were Asian (Chinese: 19.0%, Korean: 13.1%) (Table 2.1). The average age of mothers was 43.9 years (SD 7.1) and many (50.5%) had less than a high school education. While the majority of mothers were immigrants (87.7%), a large proportion (83.5%) spent at least 25% of their lifetime in the U.S. Close to two-thirds (62.1%) were aware of HPV. Mothers reported on vaccine-eligible girls who averaged 13.9 years in age. One-third of mothers reported their daughters did not have insurance or a usual source of care.

Table 2.1 also shows the proportion of girls who initiated the HPV vaccine by subgroup. Over a quarter (26.9%) of all girls in the sample initiated the HPV vaccine. The highest initiation rate was among Latinas (32.5%), with Chinese, Korean, African American and girls belonging to other racial/ethnic groups at lower rates ranging from 21% to 25%. These patterns were mirrored by interview language. Initiation rates were lower among younger girls and those with mothers who reported never having heard of HPV. Compared to girls with no insurance or private insurance, girls with public insurance had the highest rater (33.1%) of HPV vaccine initiation.

2.4.2 Geographic Access to Clinics

The distribution of Los Angeles County affiliated safety-net immunization clinics and areas where vaccine-eligible girls in the sample reside are shown in Figure 2.1. For purposes of health care delivery and planning, the county is divided in eight Service Planning Areas (SPAs). The majority of clinics are located in the metro/central (SPA 4) and south (SPA 6) Los Angeles areas of the county, where the greatest population density and poorest neighborhoods exist (LACDPH, 2010). The greatest number of low-income adolescent girls in our sample, however, resided primarily in the eastern San Gabriel Valley region (SPA 3) and south Los Angeles regions (SPA 6). Residential locations are also geographically clustered by race/ethnicity, with the majority of Latina and African American girls living in central and south Los Angeles and Chinese girls living in the eastern part of the county, providing evidence of the immigrant and ethnic enclaves within the county (Logan et al., 2002).

Geographic access using continuous distance measures (straight-line and travel) differed significantly across racial/ethnic groups (Table 2.2). Average travel distance to nearest clinic was 2.65 miles (SD: 2.02 miles, range: 0.15 – 12.25 miles) among all girls but varied significantly

($p<0.001$) across ethnic groups (Latina: 2.15 miles, Chinese: 3.47 miles). As expected, the proportion of girls with access to at least one clinic increased as the geographic radius (e.g. 1-mile radius vs. 3-mile buffer) around residences increased, with 37% of girls having access to at least one clinic within one mile of their residence and 83% of girls having at least one clinic within 3 miles of their residence. Having a clinic within 3-miles of residence also differed significantly ($p<0.001$) across ethnic groups, with ≥ 90% of Latina girls having access to a clinic within 3-miles compared to 66% of African American girls, 68% of Chinese girls and 70% of Korean girls. Similarly, driving time to the nearest clinic was longest for Chinese (7.6 minutes) and Koreans (7.5 minutes) compared to Latina (4.9 minutes) and African American (6.0 minutes) girls. These differences, although significantly different, indicate driving time to the nearest clinic is relatively short for all racial/ethnic groups in the sample. Public transportation time followed a similar pattern in terms of racial/ethnic differences but indicate that mothers without access to a personal vehicle would have to spend more than three times the amount of time (average of 21.4 minutes) to take their daughter to the nearest clinic.

2.4.3 Geographic Access and HPV Vaccine Initiation

Girls who were older (ages 11-18 compared to 9-10), Latina, covered by public insurance, those with a usual source of care, and girls whose mothers who had heard of the HPV vaccine or whose mothers were interviewed in Spanish had greater odds of initiating the HPV vaccine in the bivariate analyses (Table 3). Overall, geographic access measures were not significantly associated with HPV vaccine initiation in the bivariate analysis. Separate multivariate models were estimated for each geographic access measure (straight-line distance, travel distance, driving time, public transportation time, clinic within 3 miles). Log-transformed

straight-line and travel distance variables were also used in separate multivariate models (data not shown). Multivariate results using the travel distance and transportation time measures are shown in Table 2.3. Multivariate results for other geographic access measures are shown in Appendix 2.3. Geographic access was not significantly associated with HPV vaccine initiation at the $p<0.05$ level. For all models, mother's awareness of HPV and daughter's age, however, were consistently associated with higher odds of HPV vaccine initiation in all models, after controlling for other factors in the models.

We explored whether the relationship between geographic access and HPV vaccine initiation differed by race/ethnicity in stratified bivariate analysis and multivariate analysis controlling for interaction effects of geographic access by race (Appendix 2.1). Counter intuitively, straight-line distance, driving time or public transportation time was greater ($p<0.05$) among Chinese girls who initiated the vaccine compared to those that did not initiate the vaccine. When we examined whether geographic access had a consistent impact on initiation across racial/ethnic groups, Chinese girls were even more likely to initiate the vaccine when geographic access was greater using the straight-line distance measure (adjusted OR: 1.89, 95% CI: 1.22, 2.93). The differential relationship, however, did not hold across other measures of geographic access (travel distance, 3-mile coverage, etc).

2.5 Discussion

We found that reports of HPV vaccine initiation were very low in our sample of low-income, ethnic minority girls. Our sample's initiation rates (28%) were lower than both the national rates among low-income girls (49%) and the national 80% target immunization goal for adolescents in 2020 (U.S. Department of Health and Human Services, 2012). This disparity

points to the need to examine the factors that hinder and facilitate access to vaccination services. The idea of spatial barriers to care has long been discussed in the literature, but only recently have more studies attempted to empirically test this idea. We employ state-of-the-art techniques to estimate not only simple spatial proximity, but also to estimate the "realistic" travel distance and travel time to reach a clinic. Hence, our study is among the few to systematically examine clinic proximity as a primary correlate of HPV vaccine initiation.

Our study revealed that 8 out of 10 girls in the sample live within 3 miles of a clinic and the average commute time by public transportation to the nearest clinic is 21 minutes, suggesting low cost and free HPV vaccines are geographically accessible to populations that rely on safety-net facilities in Los Angeles County. While increased spatial access to pediatric health services were linked to increased service use among urban, low-income populations in prior studies (Fu et al., 2009; Teach et al., 2006), we did not find a similar relationship: spatial distance and commute time were not related to HPV vaccine initiation in our analysis. These null results may reflect the substantial efforts by the county's public health immunization program, private-public partnerships, and other community resources to provide accessible immunization services throughout Los Angeles County to adequately serve low-income communities. Another possible explanation may be due to selection issues and participant heterogeneity. Mothers who called our hotline are presumably more motivated that mothers who do not use hotline services. Perhaps these motivational factors also compress the variation in our sample. This implies that future research should test the hypothesis that intrinsic motivation may overcome spatial access barriers, and the corollary hypothesis that persons who are less motivated may be most severely affected by access barriers.

We did explore one dimension of participant heterogeneity related to race/ethnicity. Consistent with other findings that show disparities in geographic access to safety-net services (Cordasco et al., 2010; McLafferty, 2003; Zenk et al., 2006), our study found that proximity to low or free cost vaccinations differed across racial/ethnic groups. Our finding that Latinos had increased geographic access to care compared to other ethnic minority groups is consistent with prior literature (Hadley and Cunningham, 2004). While these difference in geographic access were statistically significant across all measures, the magnitude of differences for distance and time to nearest clinic between racial/ethnic groups were small (i.e. estimated driving time for Latina girls is on average 3 minutes shorter than for Chinese girls). Although geographic access might be similar across groups, racial/ethnic differences related to other organizational and system aspects of care, such as access to clinic appointments, wait times, language concordant care, and preferences for other clinic attributes may impact HPV initiation (Guerrero et al., 2010; Ngo-Metzger et al., 2007; Penchansky and Thomas, 1981; Stockwell et al., 2011; Weech-Maldonado et al., 2001). The inverse relationship of distance and vaccine initiation seen in the Chinese sample could be explained by additional clinic-based factors associated with vaccination behavior. Prior research has shown clinic-based factors such as targeted services for specific communities or the availability for racially or linguistically concordant providers may be stronger than the influence of distance on service use and therefore require further investigation (Ngo-Metzger et al., 2007; Traylor et al., 2010). If this is the case, the limited English proficient mothers in our sample may be more inclined to have their daughters vaccinated at clinics located within ethnic community centers despite having to travel further than their nearest safety-net clinic. Future research should explore multiple dimension of access (i.e. geographic, organizational) that influence vaccine uptake.

At the same time, our study reinforces prior research showing that mother's awareness of human papillomavirus and age of the girl to be associated with reports of vaccine initiation. Low initiation rates may therefore be due to lack of information about HPV, thus preventing mothers from seeking the HPV vaccine at safety-net clinics for their daughters. This finding further supports the growing literature showing a large proportion of parents report needing more information about the vaccine as a reason for not having their daughter vaccinated (Bastani et al.; Cates et al., 2009; Gerend and Magloire, 2008; Hughes et al., 2009). We also found, that persons with public insurance had higher rates of initiation compared to those with both private and no insurance coverage. For low-income adolescent girls, having coverage from Medicaid or public programs may be associated with having stronger ties to a usual source of care that provides continuity of adolescent care, including vaccinations (Szilagyi et al., 2008). In addition, the lower rates of vaccine initiation among privately insured girls may be reflective of the increasing cost-sharing and out-of-pocket costs for adolescent vaccines under private health insurance plans, thus leading to underinsurance among low-income girls with private insurance (Smith et al., 2009). Prior studies show families at or near the poverty level are faced with disproportionate out-of-pocket costs that limit vaccine uptake (Molinari et al., 2007). The elimination of out-of-pocket costs for all recommended immunizations under the Affordable Care Act will help to ameliorate the individual cost burden to low-income parents of adolescent girls in the future.

Our study results should be considered in light of some important limitations. Proxy-reported vaccination history by mothers raises questions about response bias. A recent study, however, showed that parental reporting of HPV vaccination had the highest validity in the National Immunization Survey compared to parental reporting of any other adolescent vaccines

(Dorell et al., 2011) Safety-net clinics, while comprehensive, may also not include all points of HPV vaccine access, such as private physician offices. The locations of where girls received the HPV vaccine were not available in our dataset. For some groups, health services may be obtained at locations closer to a school or workplace or based on clinic hours or language services. Lastly, the cross-sectional nature of the data limits our ability to make causal inferences. Nevertheless, the unique sample of low-income vaccine-eligible girls with mothers using the county health system and information on the exact residential and safety-net clinics provide practitioners provides actionable information for informing and targeting HPV promotion efforts.

While disparities in cervical cancer screening and follow-up have been widely studied, the HPV vaccine is a new preventive strategy that focuses on an age group outside the range of the population usually targeted for cancer prevention, thus relying on health care delivery programs outside of the traditional cancer screening programs. Future studies on health systems-related and contextual factors related to HPV vaccine access are warranted, especially in high-risk populations that could benefit most from the vaccine. In addition, future interventions targeted towards vaccine uptake should focus on increasing awareness about the vaccine and as well as other safety-net system factors that could improve access to the vaccine for underserved populations and ultimately reduce cervical cancer disparities.

Table 2.1 Demographic and Health Care Characteristics of Study Participants

Characteristic	Total Sample	Initiated HPV Vaccine
Mothers/Caregivers	% (n)	% (n)
Total	100.0 (479)	26.9 (129)
Race/ethnicity		
Latina	53.1 (243)	32.5 (79)
Chinese	19.0 (87)	25.3 (22)
Korean	13.1 (60)	21.7 (13)
African American	8.3 (38)	21.1 (8)
Other race	6.6 (30)	23.3 (7)
Interview Language		
Spanish	47.4 (217)	33.2 (72)
Chinese	21.0 (96)	22.8 (18)
Korean	13.3 (61)	19.7 (12)
English	17.3 (79)	28.1 (27)
Education		
< High School Diploma	50.5 (242)	29.8 (72)
High School Diploma or more	49.5 (237)	24.1 (57)
Nativity		
Foreign-born	87.7 (420)	27.6 (116)
Born in U.S.	12.3 (59)	22.0 (13)
Percent Life in U.S>		
< 25% life spent in U.S.	16.5 (79)	20.3 (16)
>=25% time spent in U.S.	83.5 (400)	28.3 (113)
Mother Heard of HPV		
Yes	62.1 (284)	41.6 (118)
No	37.9 (173)	5.6 (11)
Age (mean, SD)	43.9 (7.1)	43.4 (7.3)
Vaccine-eligible daughters		
Age		
9-10 years	14.6 (70)	5.7 (4)
11-12 years	19.6 (94)	28.7 (27)
13-18 years	65.8 (315)	31.1 (98)
Insurance status		
No Insurance	32.2 (154)	19.6 (22)
Public	56.8 (272)	33.1 (90)
Private	11.1 (53)	22.6 (12)
Have Usual Source of Care		
Yes	65.6 (314)	31.9 (100)
No	34.5 (165)	17.6 (29)

Figure 2.1 Safety-net Immunization Clinics and Residence of Vaccine- Eligible Girls by Race/ethnicity

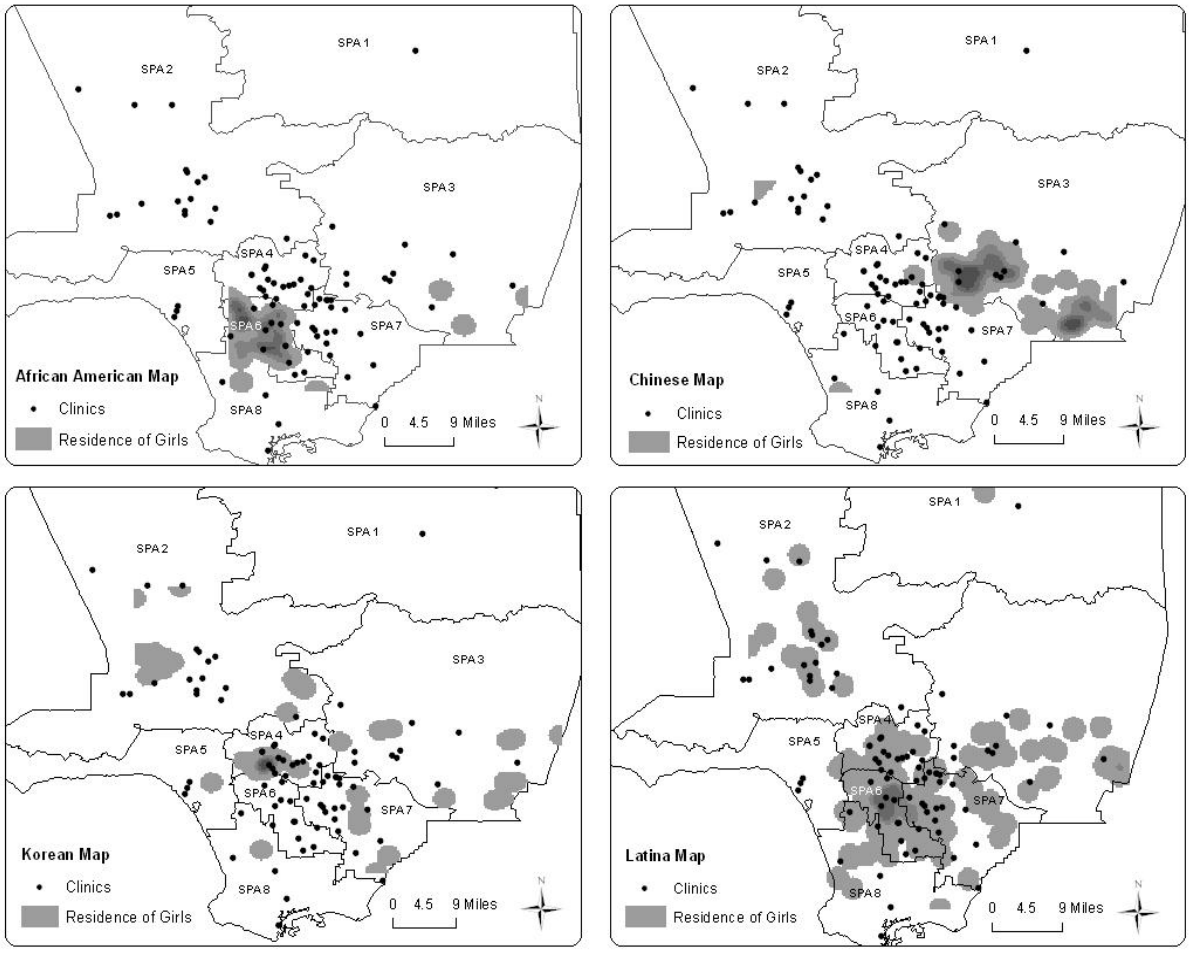

Table 2.2 Geographic Access to Safety-Net immunization Clinics by Race/Ethnicity

	All (n=479)	Latino (n=243)	Chinese (n=87)	Korean (n=60)	African American (n=38)	
	Continuous Measures of Distance to Nearest Clinic (miles), Mean (SD)					p-value^
Straight-line distance	1.71 (1.28)	1.35 (0.97)	2.39 (1.54)	2.15 (1.60)	1.64 (0.90)	<0.001
Travel distance	2.65 (2.02)	2.15 (1.47)	3.47 (2.20)	3.17 (2.94)	3.29 (2.19)	<0.001
	Continuous Measures of Time to Nearest Clinic (minutes), Mean (SD)					
Public Trans. Time	21.4 (18.1)	16.1 (9.9)	27.0 (15.6)	24.6 (15.2)	18.6 (15.0)	<0.001
Driving Time	6.22 (4.82)	4.72 (3.26)	7.62 (4.41)	7.52 (4.61)	5.97 (4.01)	<.0.001
	Categorical Measures of Having Clinic within 1, 2, 3 miles, % (n)					p-value*
Within 1 mile	36.7 (176)	46.1 (112)	19.5 (17)	35.0 (21)	23.7 (9)	<0.001
Within 2 miles	69.7 (334)	83.1 (202)	55.2 (48)	50.0 (30)	63.2 (24)	<0.001
Within 3 miles	83.3 (399)	92.2 (224)	67.8 (59)	70.0 (42)	65.8 (25)	<0.001
	Categorical Transportation Time Measures, % (n)					
<10 Minutes	24.4 (112)	29.3 (68)	15.0 (12)	20.3 (13)	12.9 (4)	<0.001
10-30 Minutes	56.5 (260)	63.8 (148)	47.5 (38)	42.2 (27)	77.4 (24)	<0.001
> 30 Minutes	19.1 (88)	6.9 (16)	37.5 (30)	37.5 (24)	9.7 (3)	<0.001

^ *P* value for one-way ANOVA F-test for differences in distance by race/ethnicity
* *P* value for Fisher's exact test for differences in proportion of girls with at least 1 clinic by race/ethnicity

Table 2.3 Bivariate and Multivariate Associations Between HPV Vaccine Initiation and Geographic Access to Clinics Among Low-Income, Minority Girls

	Bivariate OR (95% CI)	Multivariate OR (95% CI)	Multivariate OR (95% CI)
Geographic Access			
Straight-line Distance	0.93 (0.79, 1.09)	--	--
Travel Distance	0.93 (0.83, 1.03)	0.97 (0.85-1.12)	--
Clinic within 3 miles	1.04 (0.60, 1.80)	--	--
Public Transportation Time	0.99 (0.98, 1.01)	--	0.99 (0.98-1.02)
Driving Time	0.96 (0.90, 1.01)	--	--
Mother/Caregiver			
Race/ethnicity			
Latina	***1.59 (1.05-2.41)**	1.0	1.0
Chinese	0.90 (0.52-1.53)	0.74 (0.33-1.66)	0.75 (0.32-1.76)
Korean	0.72 (0.38-1.38)	1.21 (0.44-3.32)	1.62 (0.60-4.36)
African American	0.71 (0.31-1.58)	0.89 (0.28-3.51)	1.09 (0.20-5.80)
English Interview (Ref: Non-English)	1.07 (0.65-1.78)	1.04 (0.38-2.86)	1.13 (0.36-3.56)
HS Diploma or more (Ref: no HS diploma)	0.75 (0.49-1.12)	0.62 (0.33-1.17)	0.49 (0.25-0.96)
Born in U.S. (Ref: Foreign-born)	0.74 (0.39-1.42)	0.65 (0.17-2.52)	0.36 (0.07-1.85)
Age	0.99 (0.96-1.01)	0.98 (0.95-2.84)	0.97 (0.94-1.01)
Heard of HPV (Ref: No)	*****11.9 (6.19-22.8)**	*****10.4 (5.21-20.8)**	*****12.1 (5.84-25.0)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	*****7.26 (2.59-20.4)**	*****12.2 (3.59-41.3)**	*****11.7 (3.39-40.4)**
Insurance status			
Uninsured	***0.46 (0.29-0.75)**	1.0	1.0
Public	***2.13 (1.39-3.27)**	1.83 (0.89-3.78)	2.04 (0.97-4.29)
Private	0.77 (0.39-1.52)	1.06 (0.35-3.21)	1.37 (0.43-4.36)
Usual Source of Care (REF: No USOC)	***2.19 (1.38-3.49)**	1.05 (0.52-2.16)	0.89 (0.42-1.87)

Significance: * p <0.05, **p<0.01, ***p<0.001

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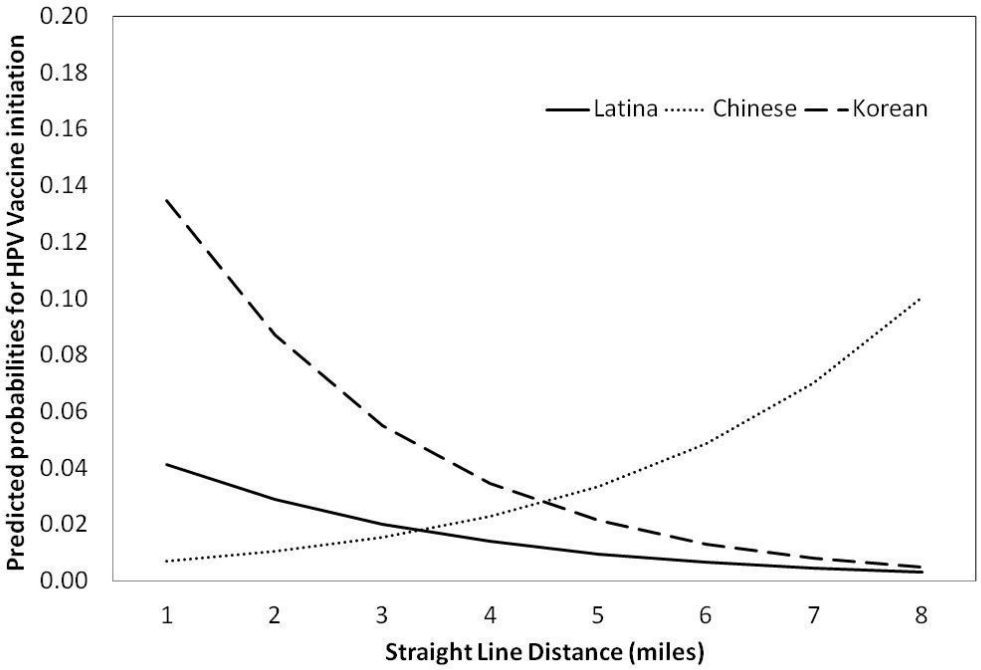
Appendix 2.1 Multivariate Associations Between HPV Vaccine Initiation and Interaction of Race/ethnicity by Geographic Access Among Low-Income Latina and Asian Girls, (n=410)

	Multivariate	Multivariate	Multivariate
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Geographic Access			
Straight-line Distance	***0.69 (0.47, 1.01)**		
Driving Distance		0.95 (0.78, 1.17)	
3-mile Buffer			1.26 (0.36, 4.35)
Mother/Caregiver			
Race/ethnicity			
Latina	1.0	1.0	1.0
Chinese	****0.17 (0.05, 0.62)**	0.85 (0.24, 2.98)	1.83 (0.39, 8.54)
Korean	2.23 (0.53-10.34)	1.16 (0.28, 4.87)	0.76 (0.10, 5.93)
Interaction of race/ethnicity and geographic access			
Chinese x geo access	****2.15 (1.27, 3.62)**	0.98 (0.70, 1.38)	0.27 (0.05, 1.43)
Korean x geo access	0.88 (0.46, 1.72)	1.01 (0.71, 1.44)	2.39 (0.27, 21.1)
English Interview	1.43 (0.49, 4.15)	1.28 (0.62, 2.63)	1.30 (0.44, 3.77)
HS Diploma or more	0.63 (0.32, 1.24)	0.65 (0.34, 1.25)	0.59 (0.30, 1.17)
Born in U.S.	0.36 (0.07, 1.97)	0.44 (0.11, 1.81)	0.38 (0.07, 2.03)
Heard of HPV	*****15.7 (7.48, 32.9)**	***** 13.1 (6.37, 27.1)**	*****14.3 (6.91, 29.6)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	*****12.7 (3.67, 44.2)**	*****11.5 (3.34, 39.2)**	*****11.7 (3.40, 40.1)**
Insurance status			
Uninsured	1.0	1.0	1.0
Public	1.44 (0.69-3.05)	1.62 (0.77, 1.73)	1.49 (0.72, 3.13)
Private	0.99 (0.32-3.08)	0.96 (0.30, 3.01)	1.05 (0.35, 3.20)
Has Usual Source of Care	1.32 (0.32-3.08)	1.26 (0.60, 2.67)	1.36 (0.64, 2.87)

Significance: * p <0.05, **p<0.01, ***p<0.001

Appendix 2.1 (cont.) Exploratory analysis of interaction between race/ethnicity and geographic access



* Based on multivariate logistic regression analyses that also adjusted for heard of HPV, interview language, education, nativity, daughter's age, daughter's usual source of care, & daughter's insurance type.

Appendix 2.2 Relative Risk Ratios from Multinomial Logistic Regression Model for Three-Level Awareness/Initiation Outcome

	Initiated HPV Vaccine vs. No Initiation & Mother NOT Aware of HPV (n=166)	No Initiation & Mother Aware of HPV Vs. No Initiation & Mother NOT Aware of HPV (n=184)
Geographic Access		
Clinic within 3 miles		
No	1.0	1.0
Yes	0.73 (0.36,1.51)	0.96 (0.50, 1.87)
Mothers' characteristics		
Age (mean, SD)	0.98 (0.95, 1.02)	0.99 (0.96, 1.03)
Race/ethnicity		
Latina	1.0	1.0
Chinese	0.63 (0.28, 1.42)	0.85 (0.41, 1.76)
Korean	0.48 (0.19, 1.22)	**0.21 (0.09, 0.52)**
African American	0.67 (0.23, 1.91)	1.15 (0.48, 2.78)
Education		
< High School Diploma	1.0	1.0
High School Diploma or more	1.24 (0.66,2.31)	**1.85 (1.04, 3.29)**
Percent Life in U.S>		
< 25% life spent in U.S.	1.0	1.0
>=25% time spent in U.S.	1.52 (0.74,3.11)	1.40 (0.75, 2.62)
Vaccine-eligible girls		
Age (mean, SD)		
9-10 years	1.0	1.0
11-18 years	**8.66 (2.90, 25.8)**	0.99 (0.55, 1.79)
Insurance status		
No Insurance	1.0	1.0
Public	**2.34 (1.16, 4.73)**	1.38 (0.73, 2.59)
Private	1.41(0.51, 43.91)	1.37 (0.55, 3.45)
Have Usual Source of Care		
No	1.0	1.0
Yes	0.97 (0.48, 1.97)	0.62 (0.33, 1.16)

Appendix 2.3 Multivariate Associations Between HPV Vaccine Initiation and Other Geographic Access Measures (Straight-line Distance, Clinic within 3 miles and Driving Time)

	Multivariate	Multivariate	Multivariate
Geographic Access	OR (95% CI)	OR (95% CI)	OR (95% CI)
Straight-line Distance	0.93 (0.75-1.16)	--	--
Travel Distance	--	--	--
Clinic within 3 miles	--	0.78 (0.37-1.62)	--
Public Trans Time	--	--	--
Driving Time	--	--	0.98 (0.92-1.07)
Mother/Caregiver			
Race/ethnicity			
Latina	1.0	1.0	1.0
Chinese	0.75 (0.34-1.66)	0.67 (0.30-1.49)	0.76 (0.34-1.70)
Korean	1.47 (0.56-3.87)	1.36 (0.52-3.56)	1.59 (0.59-4.22)
African American	0.89 (0.16-2.42)	0.95 (0.24-3.76)	1.00 (0.19-5.24)
English Interview (Ref: Non-English)	1.07 (0.36-2.87)	0.98 (0.36-2.68)	1.15 (0.37-3.59)
HS Diploma or more (Ref: no HS diploma)	0.63 (0.35-1.20)	0.62 (0.16-1.15)	0.53 (0.27-1.03)
Born in U.S. (Ref: Foreign-born)	0.62(0.19-1.70)	0.59 (0.20-1.71)	0.38 (0.07-1.93)
Age	0.98 (0.95-1.01)	0.98 (0.95-1.02)	0.98 (0.94-1.02)
Heard of HPV (Ref: No)	**11.1 (5.57-22.2)**	**11.0 (5.54-22.0)**	**10.9 (5.46-21.9)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	**12.5 (3.68-42.55)**	**12.4 (3.65-42.0)**	**11.7 (3.43-40.0)**
Insurance status			
Uninsured	1.0	1.0	1.0
Public	1.86 (0.82-3.19)	1.65 (0.84-3.25)	1.72 (0.84-3.55)
Private	1.22 (0.48-3.49)	1.30 (0.48-3.50)	1.18 (0.39-3.59)
Usual Source of Care (REF: No USOC)	1.07 (0.75-2.84)	1.49 (0.77-2.89)	1.06 (0.51-2.20)

CHAPTER 3:

Exploring the roles of neighborhood poverty and racial/ethnic composition on HPV vaccine initiation among low-income, ethnic minority girls (Study 2)

3.1 Abstract

Purpose: The recently available human papillomavirus (HPV) vaccines provide an effective new strategy for cervical cancer prevention. Vaccine initiation rates, however, are low among groups that face several barriers to utilization. While prior studies in health disparities have shown that neighborhood level factors influence health and health care use, little is known about whether neighborhood factors are associated with vaccine uptake. This study investigated the relationship between HPV vaccination among low-income, ethnic minority girls and contextual factors related to their neighborhood socioeconomic status and racial/ethnic composition.

Methods: We used data collected from a sample of largely immigrant, low-income mothers of girls ages 9 to 18 on HPV vaccine use and correlates of use ascertained via a county health telephone hotline. The 2005-2009 American Community Survey data were used to obtain neighborhood characteristics at the census tract level for each girl from the hotline sample. We compared vaccine initiation rates across levels of neighborhood disadvantage measures and employed multilevel logistic regression models to assess the effects of these neighborhood characteristics on HPV vaccine initiation (receipt $\leq$ 1 dose).

Results: Of the 483 girls in the sample, 28% initiated the HPV vaccine. Girls in the sample lived in 341 census tracts (i.e. neighborhoods) within Los Angeles County. Neighborhoods in this study were more disadvantaged compared to the rest of Los Angeles County. Low-income girls

in neighborhoods with the highest poverty had higher rates of initiation (30.4%) compared to low-income girls in neighborhoods with the lowest poverty (27%). Similarly, low-income girls in neighborhoods with the highest proportion of minority residents had higher rates of initiation (35%) compared to low-income girls in neighborhoods with the lowest proportion of minority residents (21%). Neighborhood factors were not independently associated with vaccine initiation after adjusting for individual race, age, insurance status, and mother's awareness of HPV. Mother's awareness of HPV, age of adolescent girl, and having public insurance continued to be significantly associated with vaccine initiation.

Conclusions: In general, we did not find a significant association between neighborhood factors and HPV vaccine initiation after controlling for individual level factors. Our findings that initiation rates were lowest among low-income girls in less disadvantaged neighborhoods suggests promotion efforts should be targeted towards both low-income as well as moderately-low income areas. Adolescent girls living in less disadvantaged neighborhoods may be outside the catchment of safety-net clinics, thereby facing additional geographic and information barriers to the vaccine. Interventions aimed to increase HPV vaccination should focus on improving awareness of HPV vaccines among low-income, minority mothers as well as targeting vulnerable families outside the catchment area of public vaccination programs.

3.2 Introduction

3.2.1 Cervical Cancer Disparities & HPV Vaccine

The American Cancer Society estimates that 12,710 new cases and 4,220 deaths from cervical cancer will occur in 2012 (American Cancer Society, 2012). Research continues to show that cervical cancer is unevenly distributed across socioeconomic status, racial/ethnic groups, and geography (Freeman, 2005; Krieger et al., 1999; McDougall et al., 2007; Saraiya et al., 2007; Yin et al., 2010). Despite the widespread adoption of Pap testing in the general population, disadvantaged groups often have much lower rates of screening compared to the general population (Coughlin et al., 2008; Datta et al., 2006; Tsui et al., 2007). While many studies link low screening rates to individual health insurance status, socioeconomic status, English proficiency, and lack of awareness (Coughlin and Uhler, 2000; Ponce et al., 2006), an increasing number of studies also consider cervical cancer disparities to be markers of larger social inequalities rooted in the context of geographically-based characteristics (Datta et al., 2006; Krieger et al., 2002; McCarthy et al., 2010; Singh and Miller, 2004).

The recently available human papillomavirus (HPV) vaccines provide an opportunity for a new generation of adolescents to be protected from high risk HPV infection and cervical cancer (CDC, 2007). Unless the vaccine is adopted by all subgroups, including girls that are most at risk for cervical cancer, disparities will likely remain. Some studies indicate that racial/ethnic disparities for other cancer types remain or even increase with the increasing availability yet inequitable adoption of effective medical interventions (Tehranifar et al., 2009). Recent national data indicate HPV vaccination rates are low among all groups. Only 49% of girls in the U.S. initiated the vaccine in 2010 and just 32% completed the 3-dose series (CDC, 2011). Data from 2009 also showed that initiation rates were higher among girls in low-income households

compared to girls from wealthier households (CDC, 2010). This trend may be due, in part, to the availability of free HPV vaccines via the Centers for Disease Control and Prevention's Vaccines for Children (VFC) Program as well as the increasing negative attitudes towards immunizations that are sometimes observed among higher-income, more educated parents (Dempsey et al., 2011; Smith et al., 2011).

3.2.2 Neighborhood influences on health & relationship to HPV Vaccination

While a growing number of studies have focused on individual level factors, such as psychosocial, socio-demographic, and health care characteristics, associated with vaccine uptake, little is known about whether neighborhood factors influence HPV vaccine initiation among disadvantaged adolescent girls (Bastani et al., 2011; Brewer and Fazekas, 2007; Cates et al., 2009; Constantine and Jerman, 2007; Dempsey et al., 2009; Gerend et al., 2009; Hughes et al., 2009; Rosenthal et al., 2008; Tiro et al., 2011). Prior studies have examined the influence of neighborhood characteristics on individual health status and health behaviors through a variety of pathways related to residential segregation, community level exposure to disease, availability of health care resources, and social capital (Acevedo-Garcia, 2000; Achat et al., 1998; Borrell et al., 2004; Browning et al., 2003; Kawachi and Berkman, 2003; Williams and Collins, 2001). Neighborhood socioeconomic disadvantage has specifically been associated with poorer health outcomes (Acevedo-Garcia, 2000; Diez Roux et al., 2001; Kawachi and Berkman, 2003; Subramanian et al., 2005), less access to health care resources (Williams and Collins, 2001) (Kirby and Kaneda, 2005) and lower uptake of preventive health services, including cancer screening (Coughlin et al., 2008; Datta et al., 2006; Lian et al., 2008; Schootman et al., 2006). Poorer neighborhoods are often also enclaves for a greater proportion of minority residents who

face additional barriers to care, including limited English proficiency (Ngo-Metzger et al., 2007; Ponce et al., 2006; Yang and Kagawa-Singer, 2007), limited access to health care either through lack of insurance, shortage of providers, or other factors, and discrimination in the health care system (Gee, 2008; Williams and Collins, 2001) that limit the uptake of preventive services.

If we conceptualize the influence of neighborhood disadvantage on HPV vaccination to be similar to other health services utilization scenarios, then neighborhood disadvantage (higher poverty, higher proportion of minorities) may be inversely associated with vaccine initiation. For example, lower vaccine initiation rates among girls in disadvantaged neighborhoods could be due to increased economic or logistical barriers associated with not having a usual source of care and fewer health care resources (Kirby and Kaneda, 2005). At the same time, lower vaccine initiation rates among girls living in predominantly ethnic minority neighborhoods may be due to limited access to new health information or awareness of vaccination services (Rogers, 2003). On the contrary, disadvantaged neighborhoods are targeted for the placement of safety-net services, including vaccination services, and girls from these neighborhoods may actually have more access to the vaccine. Furthermore, the VFC program subsidizes the vaccine to low-income families reducing the economic barriers to the vaccine (CDC, 2011). Ethnic minority girls living in neighborhoods with a high density of immunization clinics might be more exposed to HPV vaccine awareness campaigns and clinic outreach efforts compared to girls living in neighborhoods with fewer safety net services. Social networks might also facilitate the dissemination of information and acceptability of the vaccine among parents of low-income, ethnic minority girls living in predominantly minority neighborhoods (Kawachi and Berkman, 2000; Mobley et al., 2008; Rogers, 2003).

These competing hypotheses make it unclear whether the usual relationship between neighborhood disadvantage and lower uptake of health services holds in the case of HPV vaccination among low-income girls living in predominantly disadvantaged neighborhoods. The few recent studies that examined whether neighborhood factors were associated with HPV vaccine uptake demonstrated conflicting results. Chao et al found that girls living in poorer neighborhoods were less likely to initiate the vaccine (Chao et al., 2010) while Pruitt and Schootman showed girls living in poorer counties to be more likely to initiate the vaccine (Pruitt and Schootman, 2010). These studies had limited samples of low-income, minority girls and also used varying units of geography. Therefore, additional research is needed to understand whether neighborhood factors influence HPV vaccination in the most underserved groups.

3.2.3 Study Purpose

This study extends the current cervical cancer disparity literature to include an assessment of neighborhood socio-demographic factors on HPV vaccine initiation among underserved groups at high-risk for cervical cancer. This study employed a social ecological perspective to examine whether neighborhood poverty and racial/ethnic composition are significantly associated with HPV vaccine initiation after controlling for individual level factors. By focusing on this high-risk population, this study will contribute to the current understanding of how neighborhood context relates to vaccination. Study findings may inform the development of interventions aimed to increase HPV vaccine uptake among the neediest groups.

3.3 Materials and Methods

3.3.1 Individual Level Survey Data

This study employed individual level data previously collected from low-income caregivers of adolescent girls eligible for the HPV vaccine (ages 9 - 18 years). All study participants were recruited from the Los Angeles County Department of Public Health (LACDPH) Office of Women's Health (OWH) telephone hotline. Study participants completed interviews between January and November 2009. The OWH multi-language toll-free hotline provides services, such as scheduling of cervical and breast cancer screening appointments and providing health information, to low-income (<200% federal poverty level) and uninsured women. Callers of the hotline are women who routinely use the LAC safety-net system.

Recruitment strategies, participant eligibility, primary study findings and more detail about the OWH hotline were previously reported (Bastani et al.). Briefly, eligibility criteria included any female caller between 18 and 65 years and the medical decision-maker for at least one HPV vaccine eligible girl (9-18 years) in the household. Among eligible callers (n= 527 or 24.7% of women screened), 93% (n=490) agreed to be interviewed, representing nearly all OWH hotline callers who make medical decisions for adolescent girls. Participants were administered a 75-item telephone survey to assess their daughters' HPV vaccine uptake and correlates of uptake, and mailed a $10 grocery card incentive for participating. Because 85% of women in this larger study were mothers, rather than grandmothers, aunts, or sisters, study participants are referred to as "mothers" for simplicity. We used the addresses, HPV vaccination history, HPV awareness, and demographic data collected from participants of this larger study for the current analysis.

3.3.2 Neighborhood Data

We used data from the U.S. Census Bureau's 2005-2009 American Community Survey (ACS) 5-year estimates for neighborhood socio-demographic variables (U.S. Census Bureau, 2012). The ACS is a continuous household survey conducted in multiple languages by the U.S. Census Bureau to approximately 3 million households per year. The 5-year data was the first ACS data release that provided information for small areas, including census tracts. 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 (Krieger et al., 2002). In addition, geographical units from the census are relatively permanent and follow visible and political boundaries (i.e. counties, cities) (U.S. Census Bureau, 2008). Therefore, this study used census tracts as a proxy for neighborhoods. Geo-coded addresses of adolescent girls from the individual level data were linked to 2000 U.S. Census shape file to obtain census tract numbers within Los Angeles County. Data were then merged with the 2005-2009 ACS data by census tract.

3.3.3 Measures

HPV vaccine initiation

HPV vaccine initiation was defined as a dichotomous (yes/no) outcome for whether an adolescent girl received at least one dose of the HPV vaccine as reported by mothers. At the time of data collection, only the quadrivalent vaccine was approved for use among girls and young women. Therefore, mothers were only asked about the quadrivalent vaccine. During the interview, mothers were asked about their awareness of human papillomavirus as well as the HPV vaccine. Mothers who were aware of the vaccine (61% of total sample) were then asked

about their daughter's HPV vaccination history (i.e. whether daughter received any doses, how many doses). Mothers who reported their daughters did not receive any doses of the HPV vaccine as well as those mothers who reported no HPV vaccine awareness were categorized into the "uninitiated" group. Conversely, girls with mothers who reported they had received at least one dose of the vaccine were categorized into "initiated" group. A few mothers (n=11) that reported their daughters initiated the vaccine also reported that they were unaware of HPV. Girls in this category were still classified as part of the "initiated" group.

Individual level covariates

Other individual level variables included demographic characteristics of the respondent/mother (age, race/ethnicity), age of the adolescent girl, and insurance type of the adolescent girl. Race/ethnicity was measured as a dichotomous variable of Latina vs. Non-Latina. Latina girls were the largest subgroup in our sample and had the highest rates of HPV vaccine initiation. Since the hotline targets low-income women with an annual household income of less than 200% federal poverty level, there was limited variability in family income across the study sample and therefore excluded this variable from the analysis. For daughter's age, we used the Advisory Committee on Immunization Practices recommendations for HPV vaccines (ACIP) to transform the continuous age of adolescent girls to a categorical variable (9-10 years – pre-recommendation age group, 11-18 years – recommended age group) (CDC, 2007).

Neighborhood characteristics

We explored a number of neighborhood socio-demographic factors for this study based on previously defined measures used to for neighborhood socioeconomic (SES) and racial/ethnic composition (Kawachi and Berkman, 2003; Kirby and Kaneda, 2005) as well as prior literature related to neighborhood influence on use of cancer screening and vaccination (Coughlin et al.,

2008; Datta et al., 2006; Pruitt and Schootman, 2010). The following neighborhood variables from the 2005-2009 American Community Survey were included in the final analysis: percentage of census tract residents living below the federal poverty level, percentage of census tract residents over age 16 that is unemployed, percentage of census tract residents who are of minority race/ethnicity (i.e. those who were not Non-Hispanic white), and percentage of census tract residents without access to a private vehicle.

A factor analysis was also employed to identify a parsimonious set of neighborhood variables that would eliminate potential multi-collinearity between our neighborhood measures of interest. Variables that loaded 0.6 or more onto a factor were included. (Appendix 3.1) Our factor analysis yielded five distinct neighborhood factors: socioeconomic status, Latino, Asian, education/unemployment, and commute time. For ease of interpretation and because these factors did not vary substantially from the final variables listed above for the analysis, we did not include use factors in the final model.

3.3.4 Statistical Analysis

Descriptive & Bivariate Analyses

Initial descriptive statistics were conducted to describe the study sample and to examine the distribution of the primary outcome and predictor variables. Individual level variables were assessed for multicollinearity (e.g. Latina ethnicity and interview language). Distributions of neighborhood level variables were examined and appropriate transformations were conducted. Percentage living below poverty was categorized into quartiles for bivariate analysis. For ease of interpretation, all neighborhood level variables representing proportions were converted to standardized coefficients in the bivariate and multivariate analyses. Bivariate logistic regression

models were used to examine the association between individual level predictors and vaccine uptake.

Multivariate Analysis

Random-effects multilevel logistic regression models were employed to examine the association between individual and neighborhood level variables on vaccine uptake while adjusting for correlation between individuals living within the same census tract. We obtained odds ratios for the following multivariate logistic regression models: (1) individual level variables only, (2) neighborhood level variables only and (3) individual and neighborhood level variables together.

(1) Individual level variables only:

$$\text{Logit}\,[p(Y_i)] = \beta_{0i} + \beta_1(X_{1i}=\textit{Latino}) + \beta_2(X_{2i}=\textit{Heard of HPV}) + \beta_3(X_{3i}=\textit{Age 11-18}) + \beta_4(X_{4i}=\textit{Public ins}) + \beta_5(X_{5i}=\textit{Private ins}) + e_{0i}$$

(2) Neighborhood level variables only:

$$\text{Logit}\,[p(Y_i)] = \beta_{0i} + \beta_1(X_{1i}=\textit{Poverty Q1}) + \beta_2(X_{2i}=\textit{Poverty Q2}) + \beta_3(X_{3i}=\textit{Poverty Q3}) + \beta_4(X_{4i}=\textit{Minority}) + e_{0i}$$

(3) Individual and neighborhood level variables:

$$\text{Logit}\,[p(Y_{ii})] = (\beta_{0ij}+\mu_{0ij}) + (\beta_1+\mu_{1ij}\,(X_{1ij}=\textit{Latino})) + (\beta_2+\mu_{2ij}\,(X_{2ij}=\textit{Heard of HPV})) + (\beta_3+\mu_{3ij}\,(X_{3ij}=\textit{Age 11-18}))) + (\beta_4+\mu_{4ij}\,(X_{4ij}=\textit{Public ins})) + (\beta_5+\mu_{5ij}\,(X_{5ij}=\textit{Private ins})) + (\beta_5+\mu_{5ij}\,(X_{5ij}=\textit{Poverty Q1})) + (\beta_6+\mu_{6ij}\,(X_{6ij}=\textit{Poverty Q2})) + (\beta_7+\mu_{7ij}\,(X_{7ij}=\textit{Poverty Q3})) + (\beta_8+\mu_{8ij}\,(X_{8ij}=\textit{Minority})) + e_{0ij}$$

An average of 1.4 girls was clustered within each census tract (i.e. 341 unique neighborhoods for the 483 individual girls). We explored several regression models to properly account for the clustering of girls within neighborhoods to obtain unbiased standard errors. A multilevel model corrects the standard errors by accounting for the non-independence of

individuals within neighborhoods (Diez Roux, 2002). Models that included only the individual level variables used the traditional logistic regression. Models that included neighborhood variables only or neighborhood variables with individual level variables employed the following procedures in STATA version 10: traditional logistic regression model using the "cluster" option, a traditional logistic regression model using the "robust standard errors" option (i.e. LOGIT…., ROBUST), a generalized estimating equation (GEE), and a multilevel random-effects logistic regression model (i.e. XTLOGIT). These models showed very little differences in coefficients and standard errors. Therefore, the XTLOGIT random effects model was selected based on its ability provide estimates for individual and neighborhood variables on initiation after adjusting for within census tract differences. Statistical significance for beta coefficients will be determined at the $p<0.05$ level. Results are reported in odds ratios and 95% confidence intervals.

We also conducted multivariate logistic regression models with only individual level variables stratified by our primary neighborhood level variables of interest. (Appendix 3.2) This was done to examine whether relationships between the individual level variables and HPV vaccine initiation differed across neighborhood levels of poverty, proportion minority, unemployment, and access to a private vehicle without adjusting for clustering in the analyses.

To further explore whether there was a cross-level interaction between individual level race and the proportion of residents with the same race/ethnicity within a neighborhood (i.e. individual Asian race and proportion of Asian residents within a neighborhood), we conducted an additional exploratory analysis. (Appendix 3.3) Cross-level effects between individual level characteristics and neighborhood characteristics on health outcomes have been used in other studies (Shaw and Pickett, 2011; Winkleby et al., 2006). This model included individual race

(Latino vs. Asian), proportion of Asians and Latinos within a neighborhood, and the cross level interactions terms of individual race (Latino or Asian) and the proportion of Asians/Latinos within a neighborhood. Data for Asian subgroups at the neighborhood level were not available. Due to the small numbers of African Americans (n=38) and other race (n=30) at the individual level, we omitted these groups from this model.

3.4 Results

3.4.1 Sample Characteristics

The individual level characteristics for the study sample are shown in Table 3.1. Over half (53.1%) of mothers in the sample (n=479) were Latina and close to a third (32.1%) were Asian (Chinese: 19.0%, Korean: 13.1%). One-third of mothers reported their daughters did not have insurance or a usual source of care. Over a quarter (26.9%) of all girls in the sample initiated the HPV vaccine. The highest initiation rate was among Latinas (32.5%), with Chinese, Korean, African American and girls belonging to other racial/ethnic groups at lower rates ranging from 21% to 25%. A larger proportion of girls in the older age group, those with public insurance, and those with mother's who were aware of HPV had initiated the vaccine.

3.4.2 Neighborhood Characteristics and HPV Vaccine Initiation

We examined individual HPV vaccine initiation among adolescent girls by neighborhood poverty (Figure 3.1), minority composition (Figure 3.2), vehicle access (Figure 3.3) and unemployment rate (Figure 3.4). Girls living in neighborhoods with the lowest poverty rates (less than 10%) had an average vaccine initiation rate of 27%. Rates of initiation were highest among girls living in neighborhoods with higher poverty (Quartiles 3: 33% and Quartile 4: 30%).

Surprisingly, girls in the second to lowest poverty quartile (Quartile 2) had the lowest rates of vaccine initiation (16.7%) compared to other neighborhoods. These differences were significant at the $p<0.05$ level.

A similar pattern between HPV vaccine initiation and neighborhood poverty also existed for proportion of minority residents within neighborhoods. Rates of initiation were highest (34.8%) among girls living in neighborhoods with the largest proportions of minority residents (Quartile 4) and lowest (21.2%) among girls living in neighborhoods with the lowest proportions of minority residents (Quartile 1). There was an increasing trend in rates of vaccine initiation as the proportion of minority residents increased within a neighborhood. These differences were also significant at the $p<0.05$ level.

The relationship between HPV vaccine initiation and percent of residents with no access to private vehicles followed a pattern with neighborhood poverty and minority composition. Differences, however, were not statistically significant. The difference in rates of initiation between quartile 4 (least access to vehicles) and quartile 1 (greatest access to vehicles) was only 5%. Similarly, higher vaccine initiation rates were seen in neighborhoods with the highest unemployment rates. Neighborhoods with lower unemployment rates (Quartiles 1 and 2) had initiation rates around 22% while neighborhoods with higher unemployment rates (Quartiles 3 and 4) had initiation rates that were nearly 10 percentage points higher at 31%.

3.4.3 Neighborhood Characteristics of Sample Compared to Los Angeles County

Neighborhoods (i.e. census tracts) in this study (n=341) represented 17% of the total number of census tracts (n=2,054) in Los Angeles County (Table 3.2). On average, there were 1.4 adolescent girls per census tract. Two hundred and fifty one neighborhoods had only one girl

from the sample, 53 neighborhoods had 2 girls, 25 neighborhoods had 3 girls, 9 neighborhoods had 4 girls, and 3 neighborhoods had 5 girls from the sample. Overall, neighborhoods in the study were more disadvantaged compared to the rest of Los Angeles County. Nineteen percent of residents on average were living below poverty and another 34% had less than a high school diploma. Adolescent girls in our sample lived in primarily ethnic minority neighborhoods with large proportions of residents of Latino ethnicity (55%), followed by non-Latino Asian (17%), non-Latino African American (11%) and non-Latino White (13%). Similarly, neighborhoods had large proportions of foreign-born residents (41%) and linguistically isolated Spanish speaking households (15%). Study neighborhoods were also characterized by relatively poor transportation access. On average one in nine residents in these neighborhoods does not have access to a private vehicle.

Neighborhoods included in this study were more disadvantaged compared to the rest of LA County. For example, neighborhoods in this study had higher proportions of residents living below poverty or with less than a high school education compared to other neighborhoods. There is also a larger composition of ethnic minority residents and linguistically isolated households among the sample neighborhoods compared to the rest of the county. Additionally, a much larger proportion for residents in neighborhoods within the study take public transportation to work compared to all neighborhoods in the county (19% vs. 7%, respectively). These differences at the neighborhood level suggest girls from our county hotline sample live in poorer, less educated neighborhoods that have a higher concentration of minority and immigrant residents.

3.4.4 Bivariate and Multivariate Results

Bivariate Analysis

Unadjusted odds ratios for neighborhood-level variables on HPV vaccine initiation are shown in Table 3.3. Neighborhood level poverty was significantly associated with individual HPV vaccine initiation when categorized into distributional quartiles. Girls living in neighborhoods with poverty rates between 10-20% (Quartile 2) had 0.50 times the odds of initiating the HPV vaccine compared to girls living in other neighborhoods ($p<0.05$). On the other hand, girls living in neighborhoods with poverty rates greater than 30% (Quartile 4) had 1.79 times the odds of initiating the HPV vaccine compared to girls living in other neighborhoods. The percentage of unemployed residents was also strongly positively associated with HPV vaccine initiation at the bivariate level. Girls living in neighborhoods that have an unemployment rate of one standard deviation above the mean unemployment rate had 1.32 times the odds of initiating the HPV vaccine compared to girls living in neighborhoods with the mean unemployment rate.

Both the continuous measure for percentage of minorities living within a neighborhood and the distributional quartile categories for this variable were significantly associated with vaccine initiation. Girls from neighborhoods with one standard deviation above the mean proportion of minorities had 1.30 times the odds of initiating the HPV vaccine compared to girls living in neighborhoods with the mean proportion of minorities. Girls living in neighborhoods with the greatest proportion of minority residents (Quartile 4) were significantly more likely to have initiated the vaccine compared to girls in neighborhoods with smaller proportions of minority residents (data not shown).

Multivariate Models Adjusting for Clustering

Results from the multivariate analyses are also shown in Table 3.3. Similar to prior publications focusing on an individual level predictors for HPV vaccine initiation using this dataset (Bastani et al., 2011), mother's awareness of HPV, age of adolescent girl, having public health insurance, and Latina ethnicity were significantly associated with increased odds of vaccine uptake at the individual level (Model 1, Table 3.3).

The final neighborhood variables included poverty categorized into distributional quartiles and the standardized coefficient for percentage of minority residents. In the model with neighborhood poverty and proportion minority residents only (Model 2, Table 3.3), girls living moderately low-income neighborhoods (Quartile 2: 10-20% poverty) were 0.47 times as likely to receive the HPV vaccine compared to girls who lived lowest income neighborhoods (Quartile 4: >40% poverty). When individual and neighborhood variables were combined in the multilevel model (Model 3, Table 3.3), only mother's awareness of HPV, age of adolescent girl, and having public insurance remained significant predictors of vaccine initiation. Results were similar when the full model included only mothers aware of the HPV vaccine (data not shown).

3.5 Conclusions

In this study of low-income, ethnic minority girls, we did not find a significant association between neighborhood poverty or neighborhood racial/ethnic composition and HPV vaccine initiation after controlling for individual level factors. Results from the full multivariate model with both individual and neighborhood level factors suggest neighborhood disadvantage may not influence HPV vaccine initiation among our sample of high-risk adolescent girls. The lack of a significant association may be related to our unique sample of low-income adolescent

girls with mothers who already use safety-net services through the county health system. These mothers may be intrinsically more motivated to overcome the influences of neighborhood disadvantage on accessing safety-net services as they already utilize safety-net services for themselves. For this population of adolescent girls with parents already connected to county safety-net services, neighborhood context may be less important than other factors such as awareness of HPV and adequate insurance coverage for vaccination services.

Findings from our descriptive analyses did reveal higher rates of vaccine initiation among low-income girls living in the most disadvantaged neighborhoods. In other words, the highest rates of uptake were seen among low-income girls living in poorest neighborhoods and neighborhoods with greatest proportion of minority residents. These descriptive results, in addition to the adjusted results showing girls living moderately low-income neighborhoods (10-20% poverty) had significantly lower odds of initiating the HPV vaccine, suggest low-income girls living in relatively less impoverished neighborhoods (i.e. lower poverty rates and fewer minority residents) may face additional barriers to accessing the HPV vaccine compared to low-income girls living in the most impoverished neighborhoods. This phenomenon, contrary to the expected direct relationship between increasing neighborhood advantage and positive health outcomes or behaviors, may be explained by the increased density of safety-net immunization services in the most impoverished areas and access to subsidized vaccines via the VFC program for low-income girls (Smith et al., 2009). However, these neighborhood factors did not remain significant after controlling for individual factors and thus warrant additional investigation.

Low-income girls in our sample living in moderately low-income neighborhoods may lack nearby safety-net clinics where they can access the HPV vaccine. At the same time, mothers of adolescent girls in these neighborhoods may have limited access to in-language health

information or social networks that facilitate vaccine awareness compared to mothers living in neighborhoods with more minority residents. These inferences are supported by a recent report using the same 2005-2009 American Community Survey data employed in our study. The report showed an increasing shift in concentrated poverty in suburban areas in the late 2000s (Kneebone et al., 2011). The study also revealed that while extreme poverty census tracts (>40%) were predominantly African American, less educated, and female headed households, areas with moderately high poverty (20-40%) were comprised of greater proportions of Latino residents, foreign-born, owner occupied households, and fewer proportions of residents on public assistance. This report along with others indicate that the suburban poor often face barriers to resources that are similar to urban poor, but experience an added barrier of having fewer safety-net resources available in their immediate neighborhood (Kneebone et al., 2011; Mobley et al., 2008; Silver et al., 2010).

A more in depth geographic examination of census tracts in the county indicated neighborhoods that are moderately low-income in Los Angeles County appear to be located outside the immediate urban center and in more suburban areas (Figure 4.5). This map indicates that census tracts with 10-20% poverty are located on the perimeters of the immediate urban center and relatively further away from areas with a high density of safety-net clinics. This supports the possible underlying reasons for lower odds of vaccine initiation among girls living in neighborhoods with 10-20% poverty concentration.

Our findings of higher vaccination rates among low-income girls in the most disadvantaged neighborhoods were not consistent with findings reported by Chao and colleagues (2010) where increased household income at the census tract was associated with increased uptake (Chao et al., 2010). This study, however, was focused on adolescent girls that received

coverage from a health maintenance organization rather than a sample of girls relying on safety-net services. In terms of receiving other types of cancer prevention services, Datta and colleagues found that the odds of receiving a Pap test decreased as neighborhood poverty increased (Datta et al., 2006). In a separate study by Pruitt and Schootman (2010), girls in the poorest areas were more likely to initiate the vaccine compared to girls living in the wealthiest areas across the country (Pruitt and Schootman, 2010). However, this study used counties rather than census tracts as the unit of analysis. These contrasting results in the literature and inconsistencies in the units of analysis employed in neighborhood-level research point to a need for a greater understanding of how neighborhood socio-demographic factors influence access to and uptake of the HPV vaccine for disadvantaged populations.

Aside from mother's awareness of HPV and age of adolescent girl, which both remain strong predictors for vaccine initiation, we additionally found that having public insurance was significantly associated with vaccine uptake. The positive relationship between having public insurance (i.e. Medicaid, Healthy Kids) and higher odds of vaccine initiation may serve as a proxy measure for having a usual and affordable source of care for low-income girls. Adolescent girls with insurance coverage are more likely to receive any type of recommended vaccinations (Gowda and Dempsey, 2012). Low-income girls with private insurance, however, often face additional out-of-pocket costs for vaccinations as well as increased barriers to care (Lavarreda et al., 2011). Multiple studies have documented the sizeable increase in the costs of adolescent vaccinations over the past decade and how these costs have been passed on from insurance companies to patients (Bednarczyk and Birkhead, 2011; Smith et al., 2009). Cost-shifting disproportionately increases the financial barriers to accessing immunizations among privately insured low-income adolescent girls. Furthermore, recent studies have also noted that low

reimbursement rates for HPV vaccines as well as other vaccines have prevented doctors from recommending or providing adolescent immunizations (Freed et al., 2009; Young et al., 2011). Our study findings, combined with others, indicate a need to continue to focus on promoting vaccinations services for low-income girls who are uninsured or who may be underinsured.

While this study is one of the first to explore the relationship between neighborhood socio-demographic characteristics and HPV vaccine initiation among low-income, minority girls, some study limitations should be noted. First, due to the modest sample size and limited nesting of individuals within neighborhoods, our study serves as an initial exploration of neighborhood factors on HPV vaccine uptake. Larger samples of patients within each neighborhood would yield better power for multilevel analyses. As with many area-based studies, our analysis relied on census tracts as a proxy measure for neighborhood boundaries. While census tracts have been shown to be adequate proxies for measuring area-level factors, qualitatively defined neighborhood boundaries may be more suitable for low-income, ethnic minority populations. In addition, there may be limited variability with our study sample of low-income girls with mothers that called into a county health hotline. Lastly, due to the cross sectional nature of this data and inability to measure residential mobility, temporality may be an issue in the relationships between neighborhood factors and vaccine uptake. However, we did attempt to use temporally aligned neighborhood level data by linking to the 2005-2009 American Community Survey rather than the 2000 Census because the individual level data that was collected in 2009.

This study continues to show the need to improve HPV vaccine initiation rates among low-income, ethnic minority girls. Interventions aimed to increase vaccine uptake among vulnerable populations should focus on improving awareness of HPV vaccines among low-income, ethnic minority mothers as well as providing adequate health care coverage to

underserved populations (Gowda and Dempsey, 2012). In addition, given the recently recommended set of adolescent vaccinations, it is important that safety-net clinics serving vulnerable populations maximize on adolescent clinic visits as opportunities to provide the HPV vaccination to low-income girls (Tiro et al., 2011). Lastly, lower vaccination rates among low-income girls living in relatively less impoverished neighborhoods point to the importance of targeting vulnerable populations both within the highest need areas as well as within less impoverished areas where low-income girls may face additional barriers to accessing care. As stated by Schootman et al, merely targeting the poorest areas for uptake of cancer prevention services may leave out a large proportion of the low-income population that otherwise could benefit from preventive services (Schootman et al., 2005). Future interventions should take into account low-income adolescent girls living outside the catchment area of safety-net services who may face additional barriers to accessing vaccination services.

Table 3.1 Demographic and Health Care Characteristics of Study Participants

Characteristic	Total Sample % (n)	Initiated HPV Vaccine % (n)	No Initiation of HPV Vaccine % (n)
Mothers/Caregivers			
Total	100.0 (479)	26.9 (129)	73.1 (350)
Race/ethnicity			
Latina	53.1 (243)	32.5 (79)	67.5 (164)
Chinese	19.0 (87)	25.3 (22)	74.7 (65)
Korean	13.1 (60)	21.7 (13)	78.3 (47)
African American	8.3 (38)	21.1 (8)	78.9 (30)
Other race	6.6 (30)	23.3 (7)	76.7 (23)
Interview Language			
Spanish	47.4 (217)	33.2 (72)	66.8 (145)
Chinese	21.0 (96)	22.8 (18)	77.2 (61)
Korean	13.3 (61)	19.7 (12)	80.3 (49)
English	17.3 (79)	28.1 (27)	71.9 (69)
Education			
< High School Diploma	50.5 (242)	29.8 (72)	70.2 (170)
High School Diploma or more	49.5 (237)	24.1 (57)	75.9 (180)
Nativity			
Foreign-born	87.7 (420)	27.6 (116)	72.4 (304)
Born in U.S.	12.3 (59)	22.0 (13)	78.0 (46)
Percent Life in U.S>			
< 25% life spent in U.S.	16.5 (79)	20.3 (16)	79.8 (63)
>=25% time spent in U.S.	83.5 (400)	28.3 (113)	71.8 (287)
Mother Heard of HPV			
Yes	62.1 (284)	41.6 (118)	58.5 (166)
No	37.9 (173)	5.6 (11)	94.4 (184)
Age (mean, SD)	43.9 (7.1)	43.4 (7.3)	44.1 (321)
Vaccine-eligible daughters			
Age			
9-10 years	14.6 (70)	5.7 (4)	94.3 (66)
11-12 years	19.6 (94)	28.7 (27)	71.3 (67)
13-18 years	65.8 (315)	31.1 (98)	68.9 (217)
Insurance status			
No Insurance	32.2 (154)	19.6 (22)	80.4 (132)
Public	56.8 (272)	33.1 (90)	66.9 (182)
Private	11.1 (53)	22.6 (12)	77.4 (41)
Have Usual Source of Care			
Yes	65.6 (314)	31.9 (100)	68.2 (214)
No	34.5 (165)	17.6 (29)	82.4 (136)

Figure 3.1 HPV Vaccine Initiation Rates by Neighborhood Poverty

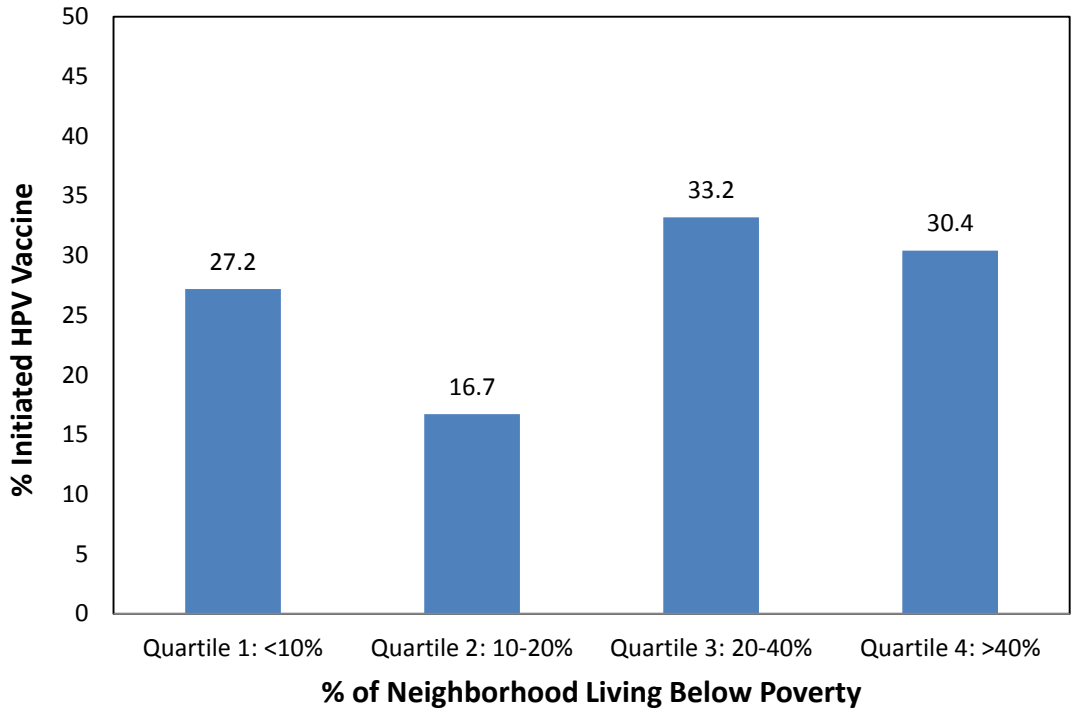


Figure 3.2 HPV Vaccine Initiation Rates by Neighborhood Racial/ethnic Composition

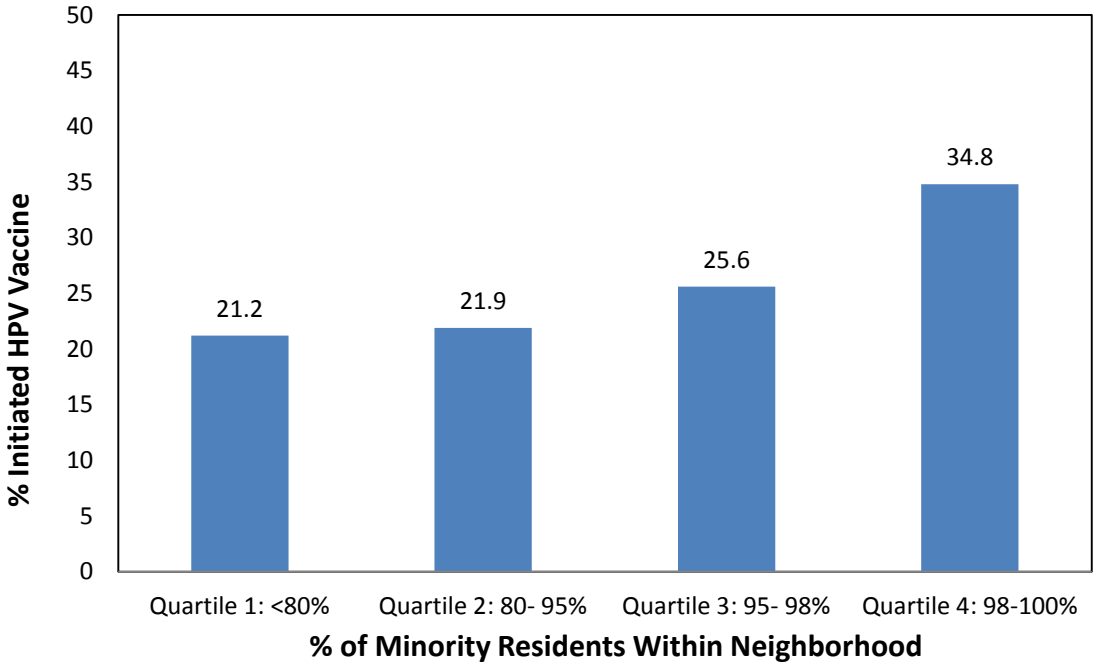


Figure 3.3 HPV Vaccine Initiation Rates by Neighborhood Rates of Vehicle Access

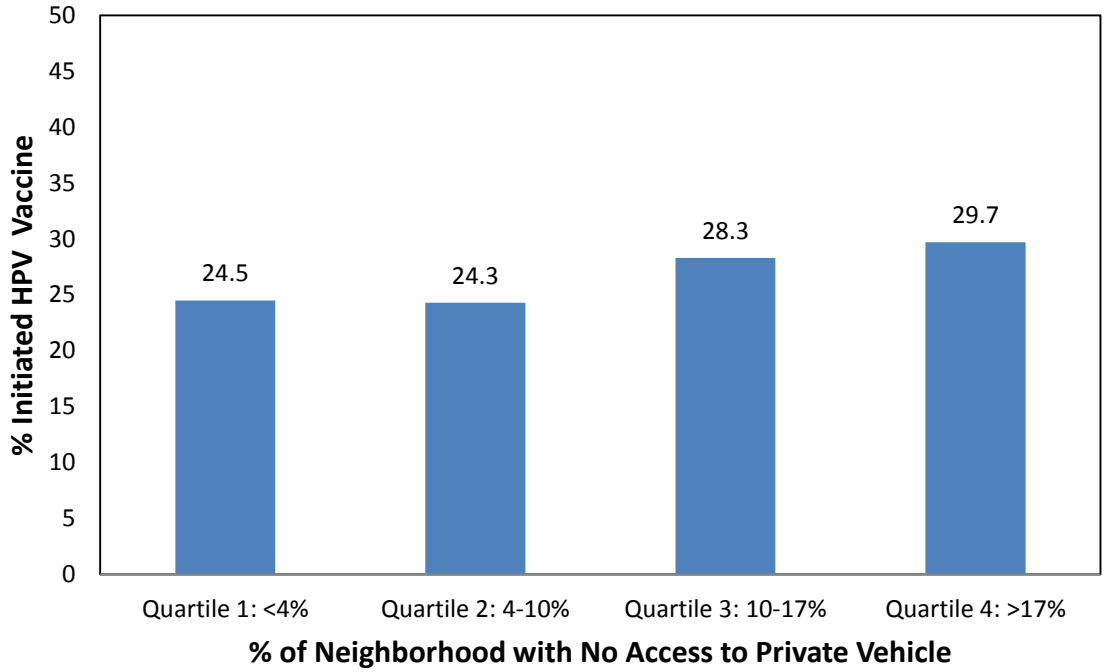


Figure 3.4 HPV Vaccine Initiation Rates by Neighborhood Unemployment Rate

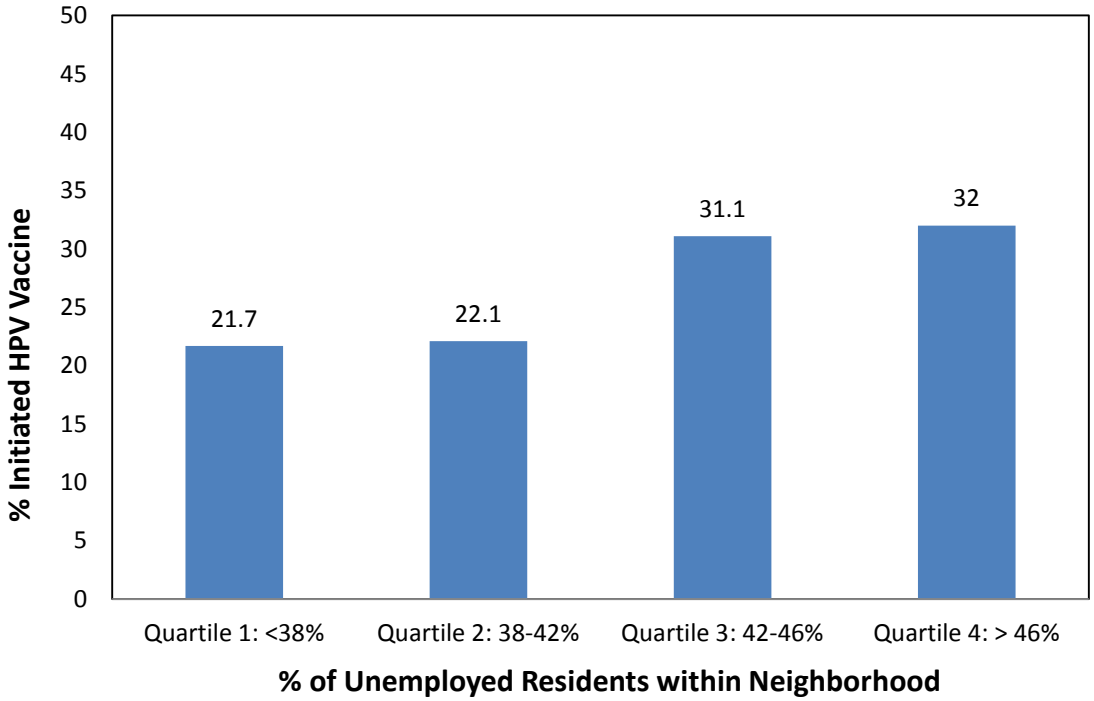


Table 3.2 Characteristics of Study Neighborhoods Compared to All Neighborhoods in Los Angeles County, 2005-2009 American Community Survey

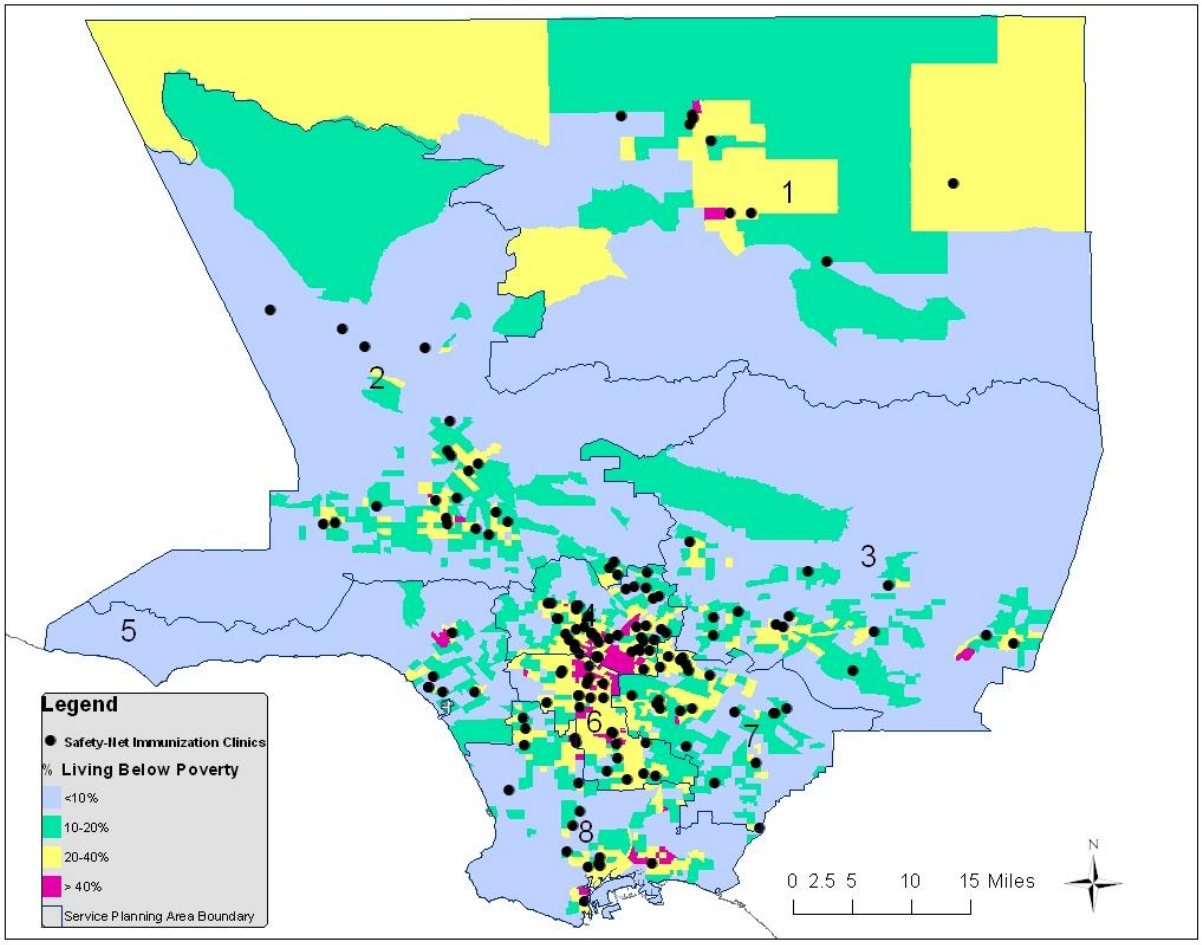
	HPV Sample (n=341 census tracts)		LA County (n=2,054 census tracts)	
Neighborhood Characteristic	Mean (SD)	Range	Mean (SD)	Range
SES				
% Living Below Poverty	0.19 (0.12)	0.003-0.61	0.16 (0.12)	0-1
% Unemployed	0.42 (0.06)	0.20-0.78	0.41 (0.09)	0-1
RACE AND LANGUAGE				
% Minority	0.87 (0.17)	0.34-1	0.70 (0.28)	0-1
% Latino	0.55 (0.29)	0.007-1	0.46 (0.30)	0-1
% Non-Latino African American	0.11 (0.17)	0-0.92	0.08 (0.14)	0-0.92
% Non-Latino Asian	0.17 (0.22)	0-0.91	0.13 (0.15)	0-0.93
% Non-Latino Other Race	0.02 (0.02)	0-0.10	0.02 (0.02)	0-0.14
% Non-Latino White	0.14 (0.18)	0-0.78	0.30 (0.28)	0-1
TRANSPORTATION				
% No access to vehicle	0.11 (0.09)	0-0.49	0.10 (0.10)	0-0.69

Table 3.3 Bivariate and Multivariate Associations Between HPV Vaccine Initiation and Neighborhood Characteristics

	Bivariate Analysis	Model 1: Individual Level Covariates	Model 2*: Neighborhood Level Covariates	Model 3**: Individual + Neighborhood
Mother/Caregiver				
Latino (Ref: Non-Latino)	**1.59 (1.05-2.41)**	**1.68 (1.03, 2.72)**		1.52 (0.87, 2.66)
Heard of HPV (Ref: No)	**11.9 (6.19-22.8)**	**10.31 (5.28, 20.1)**		**10.39 (4.99, 21.6)**
Adolescent Girl				
Age 11-18 (Ref: 9-10)	**7.26 (2.59-20.4)**	**9.4 2 (3.24, 27.4)**		**9.56 (3.16, 29.1)**
Insurance status				
Uninsured	**0.46 (0.29-0.75)**	1.0		1.0
Public	**2.13 (1.39-3.27)**	**1.91 (1.10, 3.20)**		**1.91 (1.08, 3.41)**
Private	0.77 (0.39-1.52)	1.19 (0.50, 2.80)		1.17 (0.49, 2.79)
Neighborhood Characteristic				
% Poverty Quartiles				
1 (<10%, Low Poverty)	0.99 (0.61, 1.60)		0.95 (0.44, 2.07)	0.94 (0.39, 2.23)
2 (10-20%)	**0.50 (0.30, 0.85)**		**0.47 (0.23, 0.93)**	0.53 (0.25, 1.14)
3 (20-40%)	1.01 (0.63, 1.64)		0.70 (0.38, 1.29)	0.64 (0.36, 1.21)
4 (>40%, High Poverty)	**1.79 (1.13, 2.82)**		1.0	1.0
STD_Minority^	**1.30 (1.00, 1.69)**		1.28 (0.93, 1.78)	1.09 (0.77, 1.54)
STD_Unemployment^	**1.32 (1.04, 1.68)**			
STD_No Vehicle Access^	1.10 (0.87, 1.39)			
Intraclass Correlation		0.045	0.109	0.014
AIC		449.14	559.70	
Log likelihood		-217.57	-273.85	-215.24

* Neighborhood models used logistic regression with robust standard errors.
** Two-level models used xtlogit random effects model
^ Standardized coefficients (Odds ratios represent change in one standard deviation above mean)

Figure 3.5 Neighborhood Poverty Quartiles by Census Tracts in Los Angeles County



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Appendix 3.1 Factor Analysis of Neighborhood Characteristics, American Community Survey 2005-2009. (n=341 Census tracts)

Neighborhood Characteristic	Factor 1 SES	Factor 2 ASIAN	Factor 3 LATINO	Factor 4 EDU/EMP	Factor 5 COMMUTE
Median Household Income	-0.8698				
% Living Below Poverty	0.8243				
% Home Owners	-0.9067				
% Unemployment				0.6577	
% Less than HS Diploma				0.6979	
Race					
% Latino			0.7530		
% Non-Latino African Americans					
% Non-Latino Asian		0.9116			
% Non-Latino other race			-0.6290		
% Non-Latino White					
% Linguistically Isolated –Spanish	0.6039		0.6686		
% Linguistically Isolated- Asian Lang.		0.9534			
% Foreign born		0.6899			
% Non-citizens	0.7245		0.6045		
% No access to vehicles	0.8705				
% Work commute is <30 minutes					0.8803
% Takes public transportation to work	0.7872				

* Only variables that loaded with scores >0.60 are shown above

Appendix 3.2 Multivariate Associations HPV Vaccine Initiation and Individual/Mother Characteristics Stratified by Neighborhood Level Variables

	Neighborhood Poverty		
	Low (SD Below)	Medium	High (SD Above)
Mother/Caregiver			
Latino (Ref: Non-Latino)	1.47 (0.39, 5.49)	1.43 (0.76, 2.70)	4.26 (0.74, 23.8)
Heard of HPV (Ref: No)	**5.93 (1.53, 22.9)**	**11.8 (4.52, 31.0)**	**11.9 (3.13, 45.2)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	--	**5.86 (1.67, 20.6)**	**12.6(1.44, 110.7)**
Insurance status (Ref: Uninsured)			
Public	**4.31 (1.14, 16.3)**	1.96 (0.91, 4.24)	1.03 (0.34, 3.18)
Private	2.76 (0.57, 13.4)	1.03 (0.29, 3.64)	0.34 (0.03, 4.25)
AIC	96.10	258.2	103.2
R-squared	0.15	0.20	0.27
	Neighborhood Proportion Minority		
	Low (SD Below)	Medium	High (SD Above)
Mother/Caregiver			
Latino (Ref: Non-Latino)	0.61 (0.09, 4.02)	1.43 (0.77, 2.61)	**3.80 (1.08, 13.4)**
Heard of HPV (Ref: No)	--	**9.20 (3.97, 21.3)**	**8.48 (2.59, 27.7)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	--	**6.71 (2.24, 20.1)**	--
Insurance status (Ref: Uninsured)			
Public	**7.09 (1.09, 46.2)**	1.58 (0.77, 3.26)	1.75 (0.64, 4.76)
Private	3.99 (0.42, 38.1)	0.93 (0.32, 2.71)	0.67 (0.05, 8.32)
AIC	46.7	46.7	46.7
R-squared	0.12	0.12	0.12
	Neighborhood Employment		
	Low (SD Below)	Medium	High (SD Above)
Mother/Caregiver			
Latino (Ref: Non-Latino)	1.70 (0.37, 7.92)	**1.78 (1.00, 3.15)**	1.48 (0.42, 5.23)
Heard of HPV (Ref: No)	**9.46 (1.02, 87.9)**	**11.1 (5.06, 24.3)**	**7.13 (1.39, 36.6)**
Adolescent Girl			
Age 11-18 (Ref: 9-10)	**13.4 (1.39, 129.9)**	**11.3 (2.54, 29.5)**	4.16 (0.41, 42.4)
Insurance status (Ref: Uninsured)			
Public	5.36 (0.87, 33.0)	1.83 (0.95, 3.55)	1.31 (0.39, 4.48)
Private	0.87 (0.05, 13.9)	1.78 (0.67, 4.74)	--
AIC	60.4	323.54	77.3
R-squared	0.26	0.21	0.12

Appendix 3.3 Multivariate Associations Between HPV Vaccine Initiation and Cross-Level Interactions for Individual Race and Neighborhood Race/ethnicity

	Model 1: Individual Level Covariates	Model 2: Neighborhood Level Covariates	Model 2a: Neighborhood & Cross-Level Interactions
Mother/Caregiver			
Latino (Ref: Non-Latino)	**1.68 (1.03, 2.72)**		3.09 (0.67, 25.7)
Heard of HPV (Ref: No)	**10.3 (5.28, 20.1)**		
Adolescent Girl			
Age 11-18 (Ref: 9-10)	**9.4 2(3.24, 27.4)**		
Insurance status (Ref: Uninsured)			
Public	**1.91 (1.10, 3.20)**		
Private	1.19 (0.50, 2.80)		
Neighborhood Characteristic			
% Poverty Quartiles (Ref: 4)			
1 (Lowest)		0.95 (0.44, 2.07)	
2		**0.47 (0.23, 0.93)**	
3		0.70 (0.38, 1.29)	
% Minority*100		1.01 (0.99, 1.03)	
% Neighborhood Asian			0.32 (0.01, 10.4)
% Neighborhood Latino			1.45 (0.12, 16.8)
Cross-level interaction			
Asian*% Neighborhood Asian			5.47 (0.08, 37.6)
Latino*% Neighborhood Latino			0.48 (0.03, 8.93)
Model Fit Statistics			
ICC	0.045	0.109	0.113
AIC	449.14	559.70	481.63
Log likelihood	-217.57	-273.85	-233.82

CHAPTER 4:

Are HPV Vaccination Services Accessible to High-Risk Communities in Los Angeles County? A Spatial Analysis of Cervical Cancer Risk and Safety-net Clinic Locations (Study 3)

4.1 Abstract

Purpose: In Los Angeles County, cervical cancer incidence is highest among Latina and Asian/Pacific Islander women. Geographically, incidence rates are also disproportionately greater in county's urban center. HPV vaccines represent a new strategy to prevent cervical cancer that may greatly benefit adolescent girls and young women from high-risk areas. Little is known about whether safety-net vaccination services are geographically accessible to communities at greatest risk for cervical cancer.

Methods: This study used data from the Los Angeles County Sexually Transmitted Diseases Program and the Los Angeles County SEER Registry to obtain rates of Chlamydia and HPV-related cancers at the census tract level. Hot spot analyses were conducted in ArcGIS to identify neighborhoods (i.e. census tracts) with higher cervical cancer risk. Neighborhood proximity to clinics was measured as shortest distance from neighborhood center to nearest clinic and having a clinic within 3 miles of each neighborhood center. Multivariate logistic regression models were used to estimate the associations between neighborhood cervical cancer risk and geographic access to clinics, after controlling for neighborhood socio-demographic factors.

Results: The majority of census tracts in Los Angeles County reported a Chlamydia rate of less than 5%. Few areas had greater than a 1% rate of HPV-related cancers, indicating HPV-related

cancers are rare overall. Only 37 of 386 neighborhoods with high HPV-related cancer rates and 5 of 537 neighborhoods with high Chlamydia rates lacked a clinic within 3 miles. Of these high-risk neighborhoods with limited geographic access, only two were high-poverty areas. The multivariate analysis showed neighborhood socio-demographic factors were all significantly associated with geographic access to clinics.

Conclusions: Few areas at high risk for cervical cancer were lacking geographic access to HPV vaccination services through safety-net clinics. The identification of a few specific low-income, high-risk areas points to where county immunization services can be focused on in the near future. It is important for outreach programs targeting populations relying on the safety-net system to be cognizant that low-income HPV vaccine-eligible adolescents and young women living in moderately disadvantaged neighborhoods may still benefit from services.

4.2 Introduction

Cervical cancer disproportionately burdens low income, racial/ethnic minority, and recently immigrated women in the United States (Freeman and Wingrove, 2005; Horner et al., 2011; Krieger et al., 1999; Yin et al., 2010). While overall incidence (8.7 per 100,000) and mortality (3.6 per 100,000) are relatively low, current research continues to show that cervical cancer screening, incidence, and mortality vary substantially by geography and race/ethnicity (Horner et al., 2011). In Los Angeles County, cervical cancer incidence is significantly higher than the national average with Latinas having the highest rates (13.5 per 100,000) among all ethnic groups (Liu et al., 2009; NCI, 2010; SEER, 2009). Although many studies link low screening rates to individual health insurance status, socioeconomic status, English proficiency, and lack of awareness, an increasing number of studies also consider cervical cancer disparities to be markers of larger social inequalities rooted in the context of geographically-based characteristics (Coughlin et al., 2008; Datta et al., 2006; Krieger et al., 1999; McCarthy et al., 2010; Schootman et al., 2006; Singh and Miller, 2004).

The recently available HPV vaccines provide an additional effective strategy for cervical cancer prevention among adolescents and young women. HPV vaccines prevent the infection of two high risk HPV-types (16 and 18) responsible for over 70% of all cervical cancer cases worldwide (CDC, 2007). HPV infections are also linked to the development of other cancers, including vulvar, vaginal, anal, penile, and oropharyngeal sites (Benard et al., 2008), extending the potential benefit of the vaccines. HPV vaccines are recommended by the Advisory Committee on Immunization Practices for routine use among girls ages 11 to12 years old (CDC, 2007; CDC, 2010). The quadrivalent vaccine was also recently recommended for routine use

among boys ages 11 to12 years old based on its protection against two HPV types associated with genital warts (CDC, 2011).

In Los Angeles County, free or low-cost HPV vaccines can be accessed by low-income populations through county affiliated safety-net clinics. All county-affiliated clinics receive federal funding from the Centers for Disease Control's Vaccines for Children (VFC) program to provide free vaccines to low-income children (i.e. 0-18 years of age, Medicaid enrollees, uninsured, or American Indian/Alaskan Native) (CDC, 2011). In addition, many of these county-affiliated clinics also receive federal funding from Section 317 to subsidize vaccination costs for underinsured children (Centers for Disease Control and Prevention, 2010). 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 cervical cancer.

Recent studies on HPV vaccination among adolescents from high-risk communities in Los Angeles County have explored individual psychosocial and demographic factors associated with vaccination. Two studies showed low vaccination rates (Bastani et al., 2011; Guerry et al., 2011) and revealed that awareness of the vaccine (Bastani et al., 2011) as well as having a provider recommendation (Guerry et al., 2011) were important in predicting uptake. Both studies also showed that parents of unvaccinated girls needed more information about the vaccine prior to making a decision about having their daughter vaccinated. 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 the utilization of various health services, including HIV testing, asthma management, breast cancer

screening, and childhood immunizations (Allard et al., 2003; Fu et al., 2009; Huang et al., 2009; McLafferty and Grady, 2005; Taylor et al., 2006; Teach et al., 2006). For example, 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 (Fu et al., 2009). Another study conducted by Zenk and colleagues also 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 (Zenk et al., 2006). Other similar 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 (Guagliardo, 2004; McLafferty and Grady, 2005; Sharkey et al., 2009; Cordasco et al.; Gordon-Larsen et al., 2006; McLafferty and Grady, 2005; Nykiforuk and Flaman, 2009). Therefore, it is important to examine whether safety-net clinics that provide the HPV vaccine are geographically accessible to communities that can benefit most from these services.

Limited geographic access to HPV vaccination services may be one potential contributor to low HPV vaccine uptake among low-income populations at higher risk for cervical cancer. This study examined whether neighborhood cervical cancer risk is associated with neighborhood geographic access to safety-net immunization clinics that provide free HPV vaccination services.

4.3 Materials and Methods

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." (Penchansky and Thomas, 1981). We focused on straight-line distance and having a

clinic within 3 miles of each neighborhood's center as proxy measures for this definition of access. We used three layers of geographical data. First, we obtained clinic locations from the Los Angeles County Immunization Program for all county affiliated safety-net clinics that provide the HPV vaccine for free or low cost to adolescent girls. Second, we measured neighborhood cervical cancer risk using the Los Angeles County Sexually Transmitted Diseases Program data for Chlamydia cases as well as the Los Angeles County Surveillance, Epidemiology, and End Results (SEER) registry data for HPV-related cancers cases. We linked neighborhood risk data with clinic location data to measure geographic accessibility to clinics. Lastly, we included a data layer for neighborhood socio-demographic characteristics using the 2005-2009 American Community Survey data.

4.3.1 Neighborhood Sample

We used census tracts, which include an average of 4,000 people, in Los Angeles County (n=2,052) as proxies for neighborhoods in this study. While a vast number of empirical studies examining contextual or neighborhood effects on health exist, there is limited consistency on the spatial scale used to determine area-level influences on health (Boscoe et al., 2004; Diez Roux, 2001; Kawachi and Berkman, 2003; Mobley et al., 2008; Pickett and Pearl, 2001). The inconsistency in spatial scales has led to the "Modifiable Areal Unit Problem (MAUP)," where empirical studies using different scales (county vs. zip code) show conflicting relationships (Boscoe et al., 2004; Mobley et al., 2008). 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 (Krieger et al., 2002). In addition, geographical units from the census are relatively permanent and follow visible and some political boundaries (i.e.

counties, cities) (U.S. Census Bureau, 2008). Therefore, in this study we use census tracts as proxies for neighborhoods in Los Angeles County.

For purposes of health care delivery and planning, Los Angeles County is divided in eight Service Planning Areas (SPAs). Low income, minority, and immigrant populations are concentrated in central areas of the county, primarily within SPAs 4 and 6. Geographic disparities in health outcomes and health care access in Los Angeles County also persist (LACDPH, 2009; Los Angeles County Department of Public Health, 2010), with SPAs that have higher proportions of low income, minority residents facing increased barriers to care. This study mapped census tracts as well as Service Planning Areas to provide a geographic reference of the locations of neighborhoods within the county.

4.3.2 Safety-Net Immunization Clinics

Our analyses included all clinics (n=155) affiliated with the Los Angeles County Immunization Program that provided free or low cost vaccines through the Vaccines for Children (VFC) program in 2009. These clinics encompassed health centers operated by the Los Angeles County Department of Health Services (i.e. county hospitals, comprehensive health centers), private-public partnership clinics (i.e. federally qualified health centers (FQHC), community health clinics, other private clinics that target underserved populations), and some school-based health centers that were identified by the LACDPH Immunization Program. (Appendix 4.1) A portion of these clinics are operated directly by the Los Angeles County Department of Health Services. A much larger majority of clinics (e.g. federally qualified health centers and FQHC look-alike centers), however, are operated by organizations that receive a combination of public and private funding. We examine these two types of clinics in combination and separately in the

analyses. Together, these 155 clinics serve as major points of access to primary care services, including receiving immunizations, for low-income populations within Los Angeles County. Geographic data (addresses) for clinics were obtained through the LACDPH website and confirmed with the LACDPH Immunization Program. All clinics were geo-coded using ArcGIS 10 (ESRI, Redlands, CA).

4.3.3 Neighborhood Cervical Cancer Risk Data

Currently, no systematic surveillance program exists for HPV infection cases in Los Angeles County. As an alternative, census tract level 5-year incidence rates of Chlamydia and HPV-related cancers were used as proxy measures for neighborhood level risk of HPV infection and cervical cancer. The Los Angeles County Department of Public Health's Sexually Transmitted Disease (STD) Program routinely conducts active and passive surveillance of reportable STDs (Chlamydia, gonorrhea, syphilis, and pelvic inflammatory disease) (LACDPH, 2009).The STD surveillance system gathers data from health care providers, through the Confidential Morbidity Report (CMR), and from hospitals and laboratories. Since California law requires STD cases to be reported to local health departments, surveillance data from the LADPH STD Program represent population-level STD infection rates.

This study used the five most recent years of STD incidence data (2005-2009) available for Chlamydia. Chlamydia incidence rates for each census tract serves as the first proxy measure for neighborhood cervical cancer risk because of the overlapping risk factors for acquiring this infection and HPV infection (Kahn et al., 2007). Five-year incidence rates of Chlamydia were calculated for each census tract in the county. Chlamydia infection rates have been used in other studies to identify populations at high-risk for cervical cancer (Guerry et al., 2011). Furthermore,

recent research showed that Chlamydia infection serves as a cofactor for developing cervical cancer as it increases the risk for persistent HPV infection (Franceschi et al., 2007; Lehtinen et al., 2011; Madeleine et al., 2007). Approximately, 79% of the 264,641 total incidents of reportable STD cases that occurred between 2005 and 2009 were due to Chlamydia (LACDPH, 2009).

In addition, HPV-related cancer incidence rates were used as a second proxy measure for neighborhood cervical cancer risk. 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 (SEER), is the population-based cancer registry for Los Angeles County. CSP monitors cancer cases using both active and passive surveillance (Los Angeles County Cancer Surveillance Program, 2009). We obtained estimated mean cases that occurred between 2005-2009 of the following HPV-related cancer sites based on kernel density maps provided from the CSP: cervix (female only, SEER recode 27010), vagina (female only, SEER recode 27050), vulva (female only, SEER recode 27060), penis (male only, SEER recode 28030), anus, anal canal & anorectum (both male and female, SEER recode 21060), oropharynx (both male and female, SEER recode 2008). These cancers have been linked as etiologic outcomes of persistent high-risk HPV infections. Although this study focuses only on HPV vaccination among adolescent girls, cervical cancer risk includes the rates of HPV-related cancers among males in addition to females to account for rates of HPV-related cancers that result from sexual activity.

Kernel density maps of HPV-related cancers were then intersected with the census tract layer using zonal statistics in ArcGIS 10 to obtain mean estimated cancer cases within each census tract boundary. Estimated means were divided by each census tract’s population size to

obtain estimated non-age-adjusted incidence rates. Only kernel density maps of HPV-related cancers (versus actual number of HPV related cancer cases per census tract) were available from the CSP due to confidentiality of the data.

4.3.4 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 (U.S. Census Bureau, 2008; U.S. Census Bureau, 2012). This data is temporally aligned with the LAC STD and CSP data for neighborhood cervical cancer risk. The ACS is a nationwide survey that collects annual data on demographic, socioeconomic, and housing characteristics to mirror the U.S. Census 2000 Summary File (SF-3)(U.S. Census Bureau, 2008). The annual sample size is approximately 3 million households with a response rate of over 95% (U.S. Census Bureau, 2012). The 2005-2009 multi-year ACS data was the first ACS dataset to release information at the census tract level. 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.

4.3.5 Measures

Primary Outcome: Geographic Access to Clinics

The primary outcome for this study was neighborhood geographic access to HPV vaccination services via safety-net immunization clinics. Locations of safety-net immunization clinics were spatially joined with census tracts to obtain two different geographic access

measures. The first measure was shortest distance (in miles) between the geographic centroid of each census tract and the nearest safety-net immunization clinic. We used straight-line (Euclidean) distance rather than distance over the road network because we were generalizing access from a neighborhood level and Euclidean distance provides a more conservative measure. While travel distance is more accurate, straight-line distance still allows us to examine access at a general level and compare this access across census tracts. Similar studies examining access to health facilities have also used the straight-line distance approach (Guagliardo, 2004; Zenk et al., 2006).

A dichotomous (yes/no) variable was constructed for whether at least one available immunization clinic exists within a 3-mile radius of each neighborhood centroid. Several prior studies have suggested average distance to health care facilities in urban areas is between 2 to 5 miles (Cordasco et al., 2010; Fu et al., 2009; Leibowitz and Taylor, 2007; Teach et al., 2006). This study started with a 3-mile radius for the coverage measure but also examined 1-mile and 5-mile radii as a sensitivity analysis. We used a 3-mile radius as the primary distance for comparability to other geographically based studies on health service use as well as based on the geography, population density, and travel time characteristics of Los Angeles County. Although 3-miles is not representative of a large distance in most areas, highly population dense areas of the county experience significant driving times for even the smallest distances. The dichotomous measures were obtained using the buffer, overlay, and spatial join tools in ArcGIS10. Similar geographic access measures have been used in other spatial analyses focused on access to neighborhood health care, food and physical activity resources in urban areas (Gordon-Larsen et al., 2006; Teach et al., 2006; Zenk et al., 2005).

Primary Predictor: Hot Spots of Cervical Cancer Risk

The primary predictor for this study was neighborhood cervical cancer risk as measured by rates of Chlamydia and HPV-related 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. We first 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 (neutral areas 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). A significant hot spot represents a high risk census tract surrounded by other high risk census tracts. Because the primary interest of this analysis was to examine whether neighborhoods with high cervical cancer risk have access to safety-net clinics,

we dichotomized the three level risk variables into high versus medium/low categories for the multivariate analysis.

4.3.6 Statistical Analysis

Initial descriptive statistics were conducted to profile the study sample and to examine the distribution of neighborhood characteristics across categories of cervical cancer risk. 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. Bivariate 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. Bivariate associations for the dichotomous access measure (clinic within 3 miles) were examined using logistic regression methods in STATA v 10.

Multivariate 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.

$$\mathrm{Ln}(Y_{\text{N-distance to clinic}}) = \beta_0 + \beta_1(\textit{hot spot}) + \beta_2(\textit{percent poverty}) + \ldots + \beta_n X_n + e$$

Geographic model fit statistics were obtained from ArcGIS to assess spatial autocorrelation and potential geographic variability in multivariate relationships. A significant Moran's I statistic suggests strong spatial autocorrelation in the model. Strong positive spatial autocorrelation indicates that census tracts that are closer together are more similar and neighborhoods that are further apart are more dissimilar. Not accounting for spatial

autocorrelation would violate the OLS regression assumption that the observations (each neighborhood) and errors are independent in the model (Anselin et. al., 2004). To account for spatial autocorrelation robust standard errors were used to identify significant coefficients at the $p<0.05$ level. Additionally, we explored a geographic weighted regression method in ArcGIS 10 because of the significant Koenker's statistic 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.

$$\text{Logit}(p_{\text{ clinic within 3 miles}}) = \beta_0 + \beta_1(\textit{hot spot}) + \beta_2(\textit{percent poverty}) + \ldots + \beta_n X_n + e$$

While STATA does not provide model fit statistics that incorporate geographic clustering or variation, robust standard errors were also used in this model based on indicators from the OLS regression. Coefficients from the multivariate analyses 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.

4.4 Results

4.4.1 Cervical Cancer Risk in Los Angeles County

The average Chlamydia rate for the county was 0.0194 cases per census tract or 1,940 cases per 100,000 (Std. Dev=0.07, Range 0-0.35) (Table 4.1). Chlamydia rates by census tracts are shown in Figure 4.1. The majority of census tracts had rates of less than 5%. Areas with higher rates (5-15% and >15%) are located primarily in the urban center of the county near central and south Los Angeles. Shaded areas indicate census tracts with > 25% of residents living below poverty. Although prior studies showed that increased poverty is correlated with higher

rates of STDs (Guerry et al., 2011), Figure 4.1 indicates not all areas in Los Angeles County with high Chlamydia rates are highly impoverished.

The average HPV-related cancer rate for the county was 0.0006 cases per census tract or 60 cases per 100,000 (Std. Dev=0.0024, Range 0-0.10) (Table 4.1). HPV-related cancer rates by census tracts are shown in Figure 4.2. Few areas had rates greater than a 1% rate of HPV-related cancers, indicating HPV-related cancers are rare overall. Census tracts with HPV-related cancer rates of at least 0.1-1% were primarily located in SPA 4, the central urban area of Los Angeles County, and did not fully overlap with high Chlamydia rate areas in Figure 4.1.

4.4.2 Hot Spot Analyses of Cervical Cancer Risk

The maps representing results from the hot spot analyses for Chlamydia and HPV-related cancers are shown in Figures 4.3 and 4.4. Two clusters of high Chlamydia rates are located in the Long Beach region of SPA 8 (21.5%). Similarly, hot spots for significantly higher rates of HPV-related cancers are clustered in SPAs 4 (39.8%), 6 (26.5%), and Long Beach region of SPA 8 (14.4%). High rates also extend into SPA 2 (San Fernando Valley area). From a visual perspective, these maps suggest 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 (especially in the SPA 2 and 4 border) may face some limited access to clinics.

Table 4.2 shows geographic access (i.e. distance to nearest clinic in miles) and neighborhood socio-demographic characteristics by cervical cancer risk, where hot spots in Figures 4.3 and 4.4 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 rates of Chlamydia. The average 5-year rate of Chlamydia per census tract among hot spots was 4.1% or 4,100 per

100,000. Distributions for socio-demographic characteristics were similar to those seen for HPV-related cancer rates.

A total of 536 of the 2052 census tracts were high risk for cervical cancer based on HPV-related cancer rates. These high risk areas had an average HPV-related cancer rate of 0.13% or 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. Overall, high risk neighborhoods had significantly higher rates of residents living below poverty, with less than a high school education, 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.

The difference between the proportions of African American and Latino residents in high risk versus low risk areas of Chlamydia were much greater compared to the differences in proportions for HPV-related cancers. For example, the average proportion of Latino residents in high risk Chlamydia areas was 65.3% compared to 15.4% in low risk areas. The average proportion of Latino residents in high risk HPV cancer areas was 55.6% compared to 44.6% in low risk areas. Chlamydia hot spots are frequently located in ethnic minority neighborhoods while HPV related cancer hot spots are not as concentrated in minority areas.

4.4.3 Geographic Access to Clinics among High Risk Areas

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 (Table 4.2). These 5 census tracts are located on the border of SPA 4 and 6 in South Los Angeles, West Adams neighborhoods (Figure 4.5). These census tracts with limited geographic access to clinics were

also less disadvantaged compared to tracts with greater access to clinics. However, contrary to expectations, census tracts that were characterized by limited geographic access to clinics based on Chlamydia rates had higher proportions of African American residents than census tracts with greater access to clinics (Table 4.2).

Among the 536 census tracts that were high risk based on HPV-related cancer rates, 37 did not have a clinic within at least 3 miles of each census tract's centroid (Table 4.2). 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. Census tracts with limited geographic access to clinics were primarily located in the western region of SPA 4 and the south eastern region of SPA 8 (Figure 4.6).

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 Long Beach area of SPA 8 and the Pico-Roberston area of SPA 4. Both SPAs are located in the outer periphery of the poor urban core of Los Angeles County (Figure 4.6).

4.4.4 Geographic Access to Clinics among High Risk Areas by Clinic Type

Of the 155 Los Angeles County Immunization Program affiliated immunization clinics, 23 were operated by the Los Angeles County Department of Health Services (DHS) and 132 were operated by private-public partnership clinics, not-for-profit clinics, and other community based organizations. Figure 4.7 shows DHS clinics and other clinics (private-public partnership clinics) separately and corresponding HPV-related cancer hot spots. A total of 205 hot spots with

limited access to clinics (i.e. no clinic within 3 miles) exists when examining only county operated clinics compared to a total of only 37 hot spots with limited access to clinics when examining both DHS clinics and other clinics together (Figure 4.4). Similar relationships were seen when examining Chlamydia rates (Figure 4.8).

4.4.5 Bivariate and Multivariate Models for Distance to Clinic

Table 4.3a and 4.3b show the bivariate and multivariate log-linear regression for distance to nearest clinic (log transformed in miles) with HPV related cancer hot spots and Chlamydia hot spots as primary predicators. Bivariate regression showed hot spots and all socio-demographic factors (aside from percent White and percent Asian) to be inversely associated with log-distance to clinic, indicating that neighborhood disadvantage and cervical cancer risk were significantly associated with being closer to a clinic.

Geographic model fit statistics in ArcGIS 10 for the multivariate models showed a significant Moran's I statistic, indicating strong spatial autocorrelation in the model. In other words, cervical cancer risk in one neighborhood is correlated with cervical cancer risk in adjacent neighborhoods. Therefore, robust standard errors were used to best acknowledge spatial autocorrelation and to identify significant coefficients conservatively at the $p<0.05$ level.

After controlling for neighborhood socio-demographic factors in both the reduced model (socioeconomic factors only, Model 1, Table 4.3a and 4.3b) and the full model (socioeconomic factors and racial/ethnic composition, Model 2, Table 4.3a and 4.3b), Chlamydia and HPV cancer hot spots no longer remained significantly associated with distance to clinic. The OLS regression also produced a significant Koenker's statistics which suggests that the relationships between the predictors of interest and log-distance to clinic may differ across geographic areas.

An exploratory geographic weighted regression method in ArcGIS 10 was used to see if the relationship between hot spots and distance to nearest clinic differed across regions. Findings from this analysis suggests a negative relationship between distance to clinic and cervical cancer risk within the inner city areas (SPAs 4, 6, and 8) and a positive relationship between distance to clinic and cervical cancer risk in more suburban areas outside the county's center (SPAs 1, 2, and 5). Therefore, in inner city areas clinics were more likely to be located within or in close proximity with high cervical cancer risk neighborhoods. However, in the outer boundaries of the inner city and in more suburban areas clinics were less geographically accessible (i.e. further away) from the highest risk neighborhoods.

4.4.6 Bivariate and Multivariate Models for Clinic Location within 3 Miles

Lastly, Table 4.4a and 4.4b show the bivariate and multivariate logistic regression results for having a clinic within a 3-mile radius of each neighborhood centroid. Bivariate analyses indicated neighborhood hot spots for high cervical cancer risk (Cancer hot spot: OR 3.60, 95%CI 2.53, 5.15; Chlamydia hot spot: OR 20.4, 95% CI 8.38, 49.7%) were significantly associated with having a clinic within a three mile radius. The positive association between most neighborhood socio-demographic factors (aside from percent White and percent Asian) and having a nearby clinic (i.e. within a three mile radius) suggests disadvantaged neighborhoods were more likely to have a nearby clinic compared to less disadvantaged neighborhoods.

To fully examine whether neighborhood hot spots have geographic access to clinics, it is important to control for neighborhood disadvantage characteristics because safety-net services are primarily located in medically underserved low-income areas. After controlling for neighborhood poverty, education, and access to private vehicles (Model 1 in Tables 4.4a and

4.4b), the relationship between Chlamydia hotpots and having a clinic with three miles remained significant while the relationship between cancer hot spots and having a clinic within three miles was no longer significant. This may reflect the notion that areas with high Chlamydia rates have characteristics related to being medically underserved and thus are more likely to have access to a nearby safety-net clinic. On the other hand, cancer hot spots do not fully overlap with high poverty areas as seen in Figures 4.2 and 4.4. After controlling for neighborhood poverty, cancer hot spots are no longer more likely to be in the same areas as clinics. After controlling for neighborhood racial/ethnic composition, citizenship status, and linguistic isolation in addition to neighborhood socioeconomic measures (Model 2, Tables 4.4a and 4.4b), the relationship between Chlamydia hot spots and having a clinic within a three mile radius also was no longer significant. The primary neighborhood level predictors for having a clinic, however, do continue to be significant. Percent of Latino residents within a neighborhood was the strongest predictor for having a clinic within three miles. Neighborhoods that fell within one standard deviation above the mean for percent of Latino residents had a 2.08 times greater odds (95% CI: 1.46, 2.82) of having a nearby clinic compared to neighborhoods with the county mean percent of Latino residents.

4.5 Discussion

Using geographic information system mapping techniques, this study identified very few neighborhoods with high cervical cancer risk that were lacking geographic access to HPV vaccination services through safety-net clinics in Los Angeles County. The majority of neighborhoods with the highest risk were primarily located in the central and southern Los Angeles County service planning areas. These areas happen to overlap with low-income areas

that have a substantial number of both county–operated and private non-profit safety net clinics. Overall, results of this study confirm that HPV vaccination services are for the most part geographically accessible to high-risk communities in Los Angeles County, with the exception of a few specific areas that are not well served with respect to HPV vaccination services. Two high-risk neighborhoods, located in the Long Beach/Belmont Shores area in SPA 8 and the West Adams/Pico-Robertson/Mid-city area in SPA 4, may benefit from increased geographic access to HPV vaccination services. Both neighborhoods experienced about a10% poverty increase between 2000 and 2010 and even greater increases 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 cervical cancer risk is high.

Most high risk neighborhoods that lacked a nearby clinic were not the most socioeconomically disadvantaged neighborhoods. However, it is important to note that, low-income residents who live in these slightly less impoverished neighborhoods may face greater geographic barriers to accessing safety-net immunization services compared to their counterparts living in more disadvantaged neighborhoods. Low-income girls who do not live in the most disadvantaged neighborhoods where safety-net services are targeted may in turn have more difficulty accessing safety-net immunizations services. Therefore, it is important for vaccination outreach programs to be cognizant that low-income HPV vaccine-eligible adolescents and young women living in moderately disadvantaged neighborhoods may still rely on and benefit from safety-net services.

With over 10 million residents, Los Angeles County is the most populous county in the United States. In times of scarce resources, it is more efficient for the Los Angeles County Public

Health Department to identify very specific areas of need and then to direct preventive services to these underserved high-need populations. While current services for HPV vaccination seem mostly geographically distributed to areas of need, the use of GIS to map high risk areas and identify neighborhoods with limited access to care can be useful for directing future safety-net services. Study results also indicate that the partnership of the county public health department with private safety-net clinics substantially enhances the geographic reach of safety-net services within Los Angeles County. This reflects the large role public-private partnership clinics and other non-county run clinics play in serving areas of need within the county. Furthermore, it reflects the expansive geographic coverage that the county health department and partnering organizations serves for safety-net immunization services. This type of partnership falls in line with the increased focus on multi-organizational partnerships between county public health systems and health care organizations to improve population health (Mays and Scutchfield, 2010).

Despite the fact that immunization services are geographically available and costs are reduced through the VFC program, the low uptake of HPV vaccines among adolescent girls in the county suggests 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 (Lau et al., 2012), coupling HPV vaccination with other office visits (Vadaparampil et al., 2011), and reminder systems for on-time vaccinations (Kharbanda et al., 2011) may enhance uptake of the vaccine. Several studies have shown provider recommendation (Guerry et al., 2011; Young et al., 2011) and missed opportunities (Tiro et al., 2011; Vadaparampil et al., 2011) 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 avenues (Short et al., 2005). Lastly, other political avenues aimed to increase preventive care, including health care reform and potential school mandates, may have a larger impact on improving vaccination 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 (Robitz et al., 2011). 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 (Smith et al., 2005; Szilagyi et al., 2008).

While this study provided policy relevant information for local immunization program leaders and cancer control researchers, some limitations should be mentioned. First, neighborhoods in this study were defined by census tracts. 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 (Krieger et al., 2005). Little is known about whether definitions of neighborhoods differ by race/ethnicity (Diez Roux, 2001) and whether certain groups prefer to use health services near ethnic community centers outside of their immediate neighborhood. Second, this study defines geographic access using a 3-mile cutoff. Although recent studies have used a range between 2 to 5 miles as an appropriate cutoff to measure accessible distances to health services, there is limited research about whether 3-miles is a valid distance for all urban (and suburban) areas as well as all racial/ethnic groups. Third, this study used Chlamydia and

HPV-related cancer rates as proxies for cervical cancer risk. While no routine HPV surveillance program exists, it may be more accurate to use a multifactor risk measure that incorporates both disease incidence and socio-demographic risk factors for cervical cancer. Lastly, this ecological study is unable to identify causal relationships between individual geographic access to clinics and uptake of the HPV vaccine.

Despite the limitations of this study, this type of analysis provides useful information for public health programs to allocate resources to areas with the greatest need, especially for novel disease prevention strategies. This study used temporally aligned STD surveillance data, cancer registry data, census data, and a list of safety-net clinics affiliated with the Los Angeles County Immunization Program that provided an exploratory look at cervical cancer risk available safety-net HPV vaccination services for Los Angeles County. Study results point county immunization program leaders and cancer control leaders to direct their attention to utilizing services and clinics that are already in place rather than trying to increase the reach and number of safety-net immunization facilities for the majority of high-risk areas.

Table 4.1 Neighborhood Characteristics by Cervical Cancer Risk

Neighborhood Characteristics	HPV-Related Cancers			Chlamydia Rate		
	High n=536	Medium n=912	Low n=604	High n=386	Medium n=1488	Low n=178
	% (SD)	% (SD)	% (SD)	% (SD)	% (SD)	% (SD)
Cancer/Chlamydia Rate (mean, SD)	0.13 (0.45)	0.05 (0.06)	0.02 (0.02)	4.1 (2.7)	1.5 (0.8)	0.7 (0.4)
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)
% 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 education	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)
% 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)

Figure 4.1 Chlamydia Rates by Census Tracts in Los Angeles County

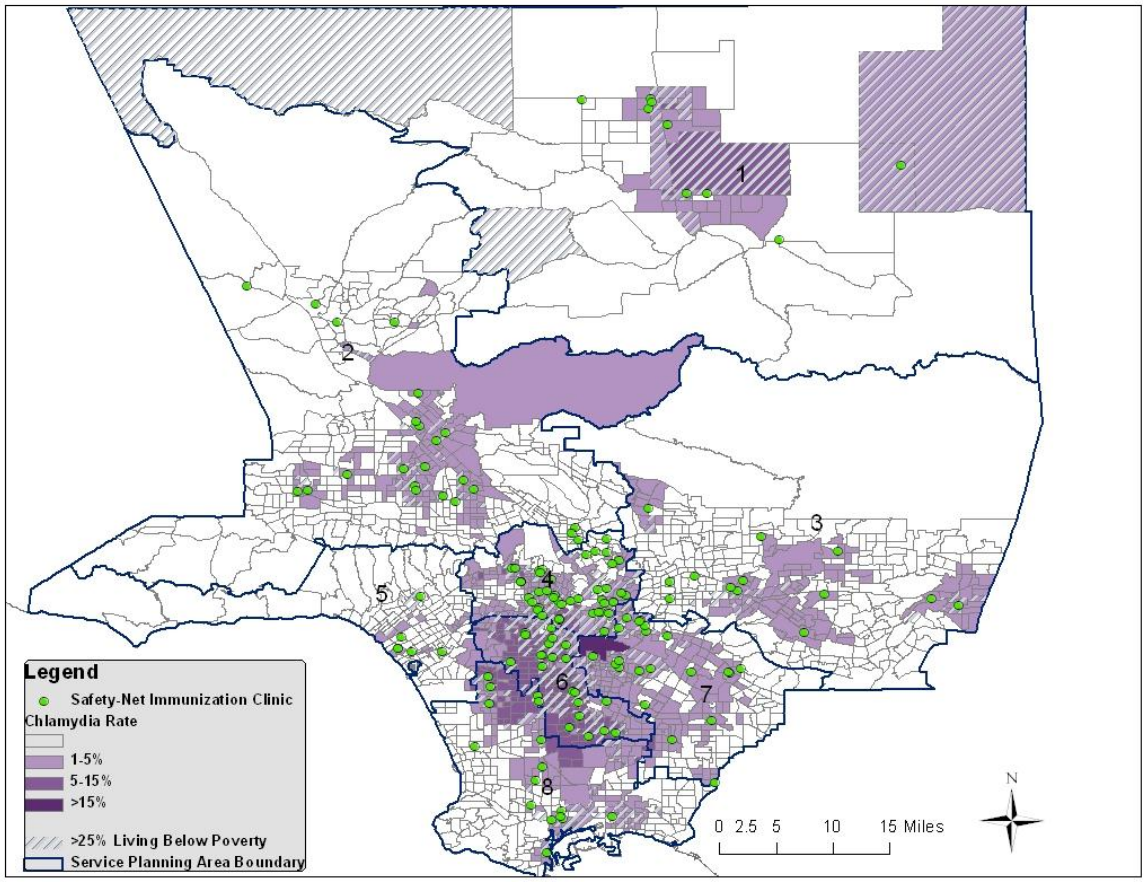

Figure 4.2 HPV-Related Cancer Rates by Census Tracts in Los Angeles County

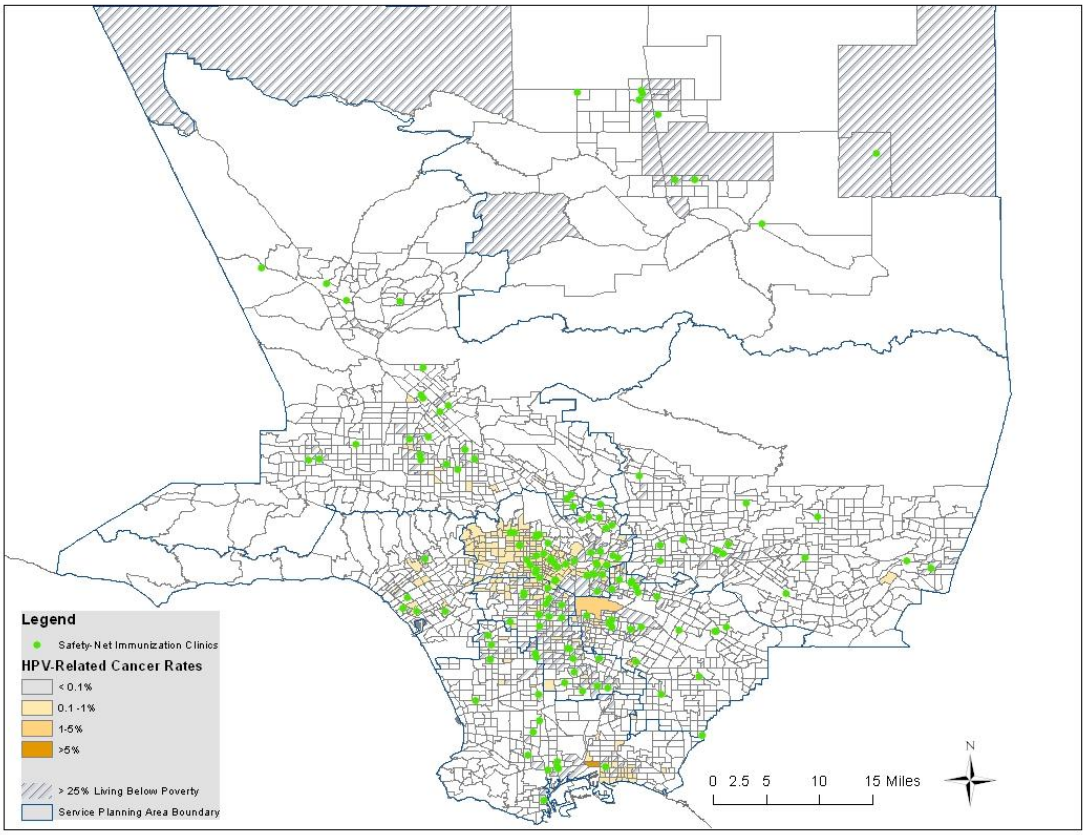

Table 4.2 Characteristics of Hot Spots by Geographic Access to Clinics

	High HPV-Related Cancer Areas			High Chlamydia Areas		
Neighborhood Characteristics	Clinic within 3 miles n=499	No Clinic n=37	p-value	Clinic within 3 miles n=381	No Clinic n=5	p-value
	% (s.e.)	% (s.e.)		% (s.e.)	% (s.e.)	
% Living below pov	25.9 (13.5)	11.0 (6.7)	<0.001	28.1 (13.4)	19.8 (9.3)	<0.001
% Less than HS edu	38.2 (20.2)	11.3 (12.1)	<0.001	43.9 (16.5)	28.5 (17.6)	<0.001
% No Vehicle	19.8 (12.4)	8.2 (4.9)	<0.001	18.9 (13.1)	13.3 (5.0)	<0.001
% White	43.0 (20.1)	65.4 (24.0)	<0.001	33.0 (16.5)	23.3 (9.6)	<0.001
% African American	13.2 (17.8)	13.8 (16.4)	<0.001	24.5 (23.1)	40.8 (18.7)	<0.001
% Asian	9.6 (12.8)	6.5 (4.0)	<0.001	4.7 (9.0)	5.2 (4.6)	<0.001
% Latino	58.1 (29.3)	21.2 (19.9)	<0.001	65.6 (25.2)	46.8 (26.0)	<0.001
% Non-Citizen	29.8 (14.1)	11.3 (7.4)	<0.001	29.4 (13.4)	18.1 (9.9)	<0.001
% Linguistically Isolated	8.5 (5.7)	3.3 (2.5)	<0.001	7.2 (5.4)	4.9 (2.6)	<0.001

Figure 4.3 Hot Spot Analysis of Chlamydia Rates in Los Angeles County

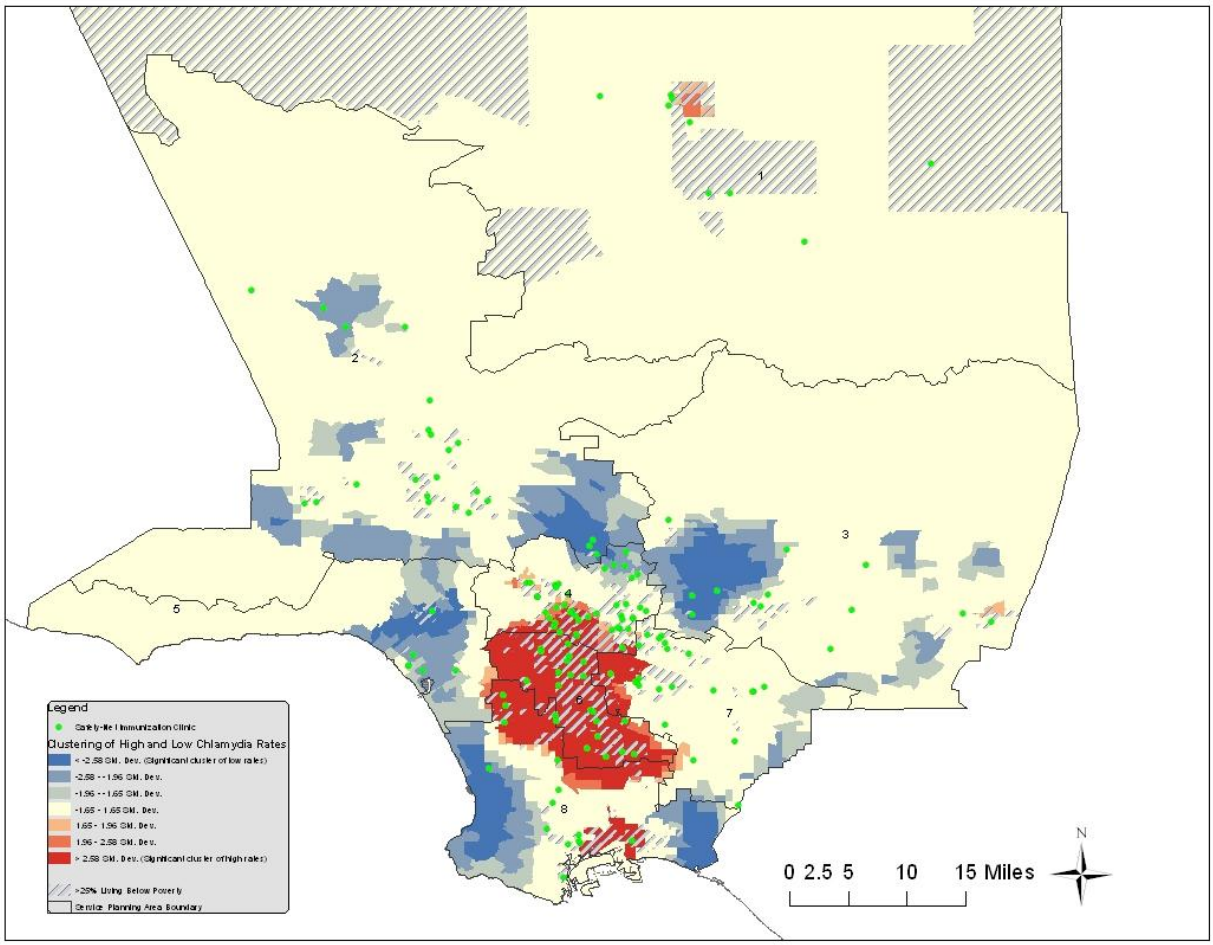

Figure 4.4 Hot Spot Analysis of HPV-Related Cancer Rates in Los Angeles County

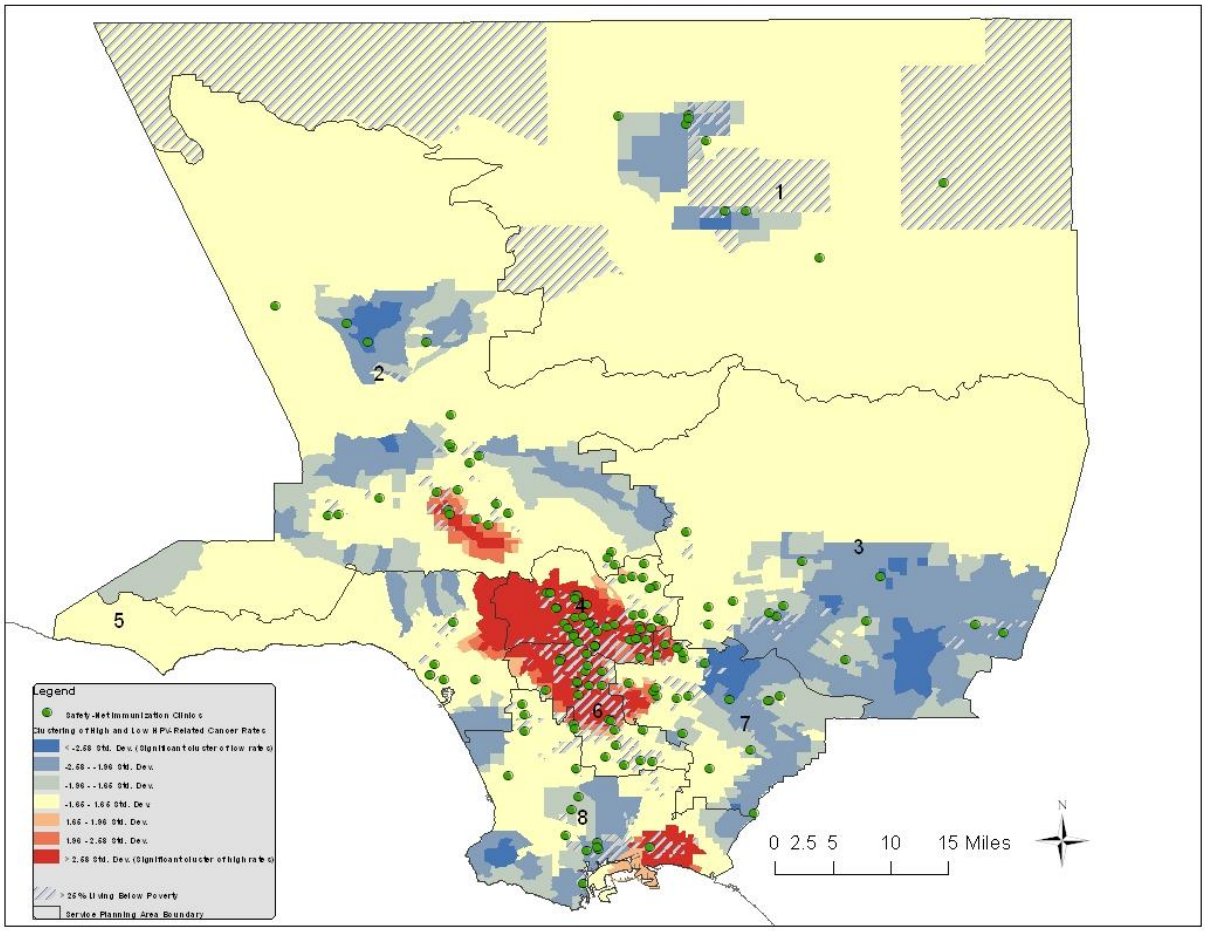

Figure 4.5 High Risk Chlamydia Neighborhoods with Limited Access to Clinics

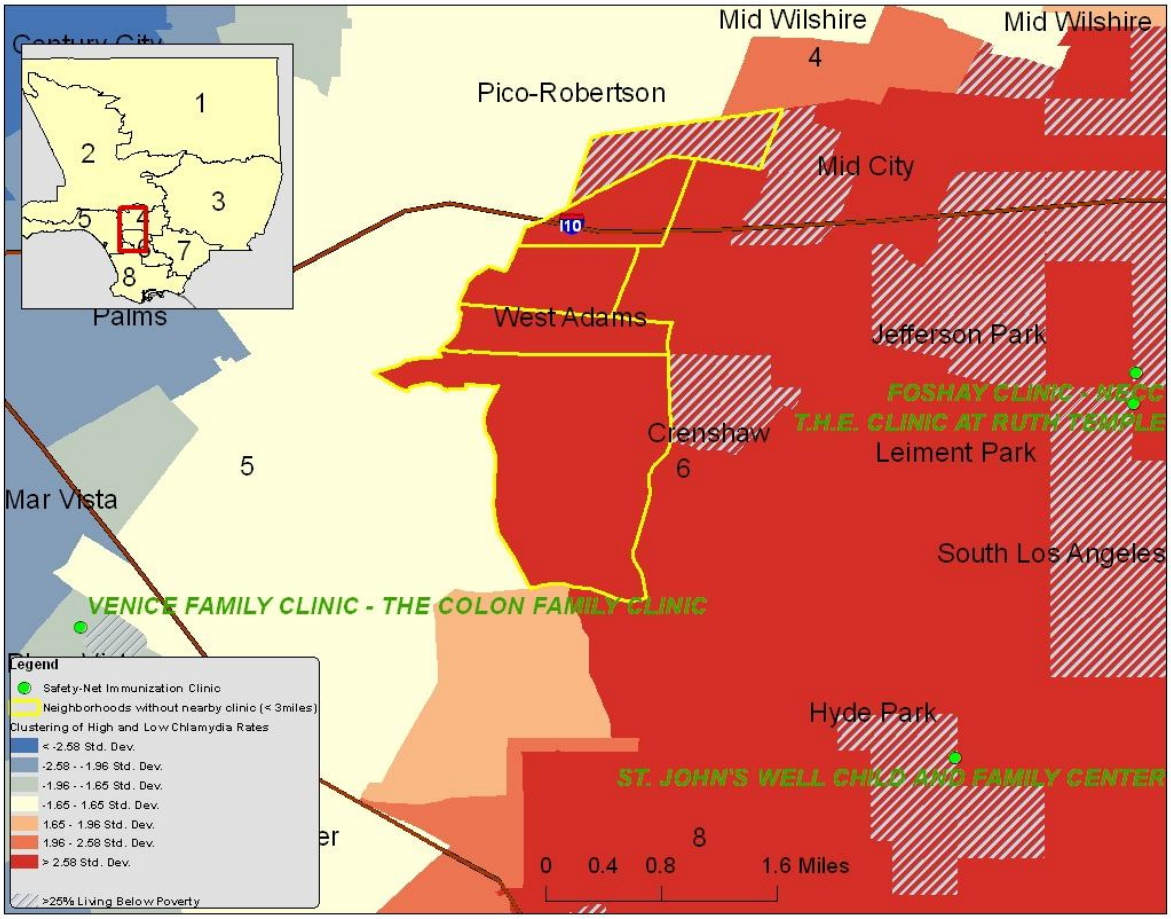

Figure 4.6 High Risk HPV-Related Cancer Neighborhoods with Limited Access to Clinics

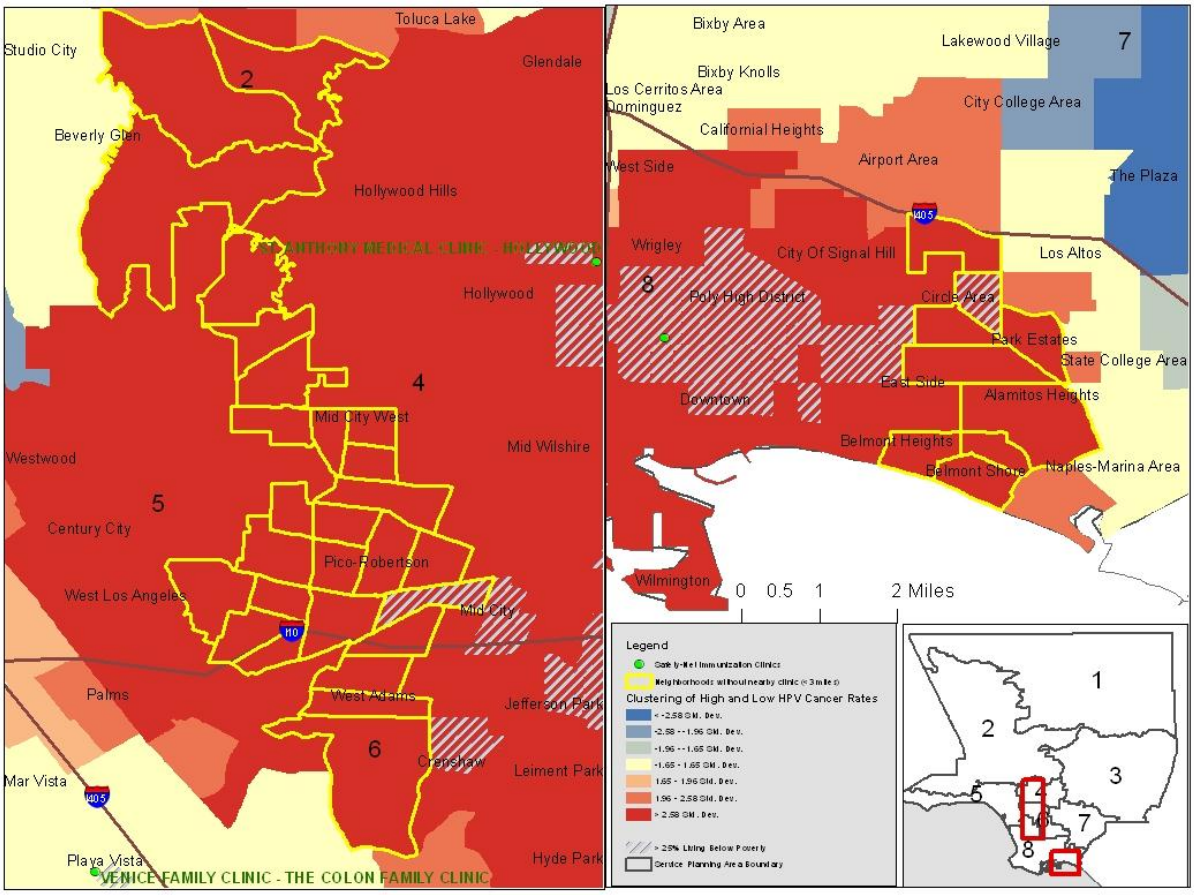

Figure 4.7 Hot Spots of High Chlamydia Rates with Limited Access to Clinics by Clinic Type

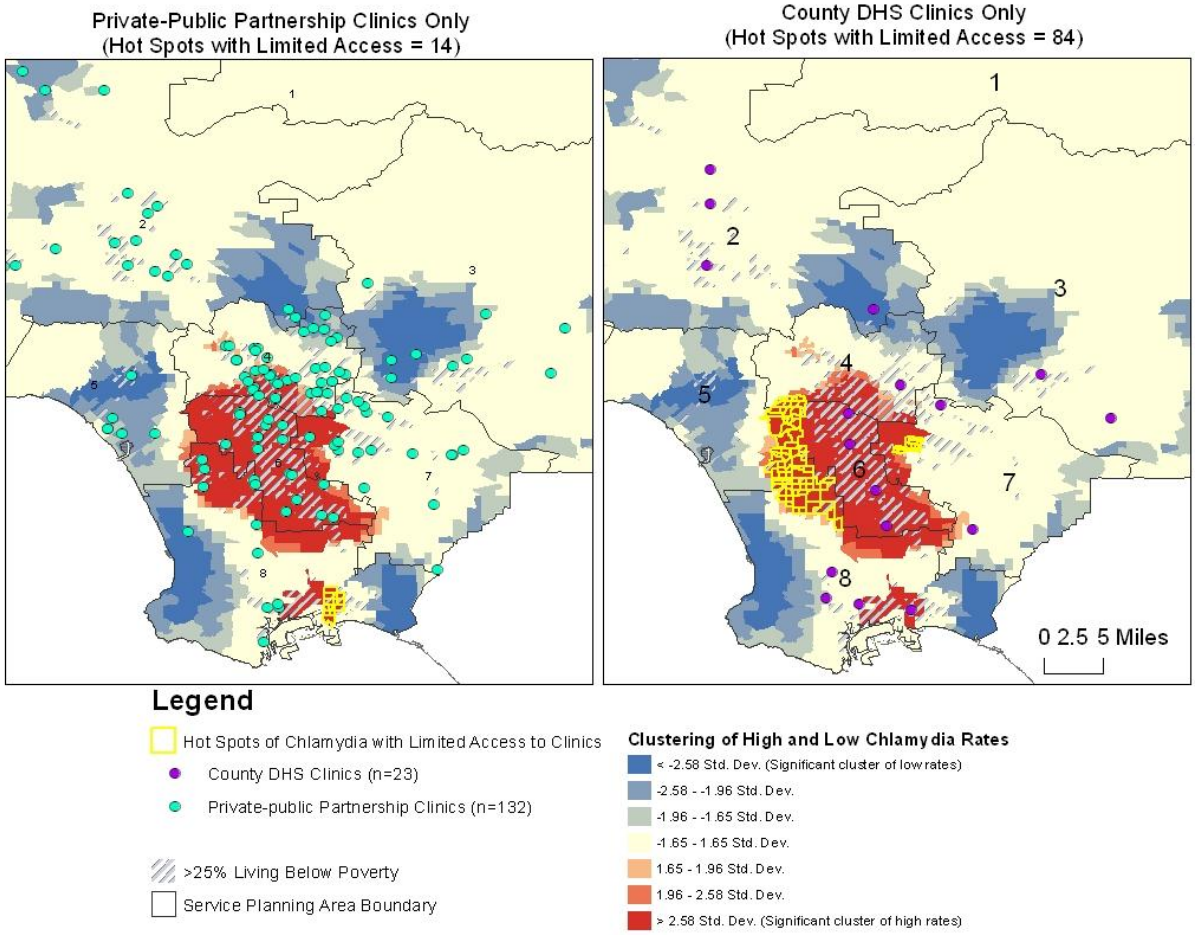

Figure 4.8 Hot Spots of High HPV-Related Cancer Rates with Limited Access to Clinics by Clinic Type

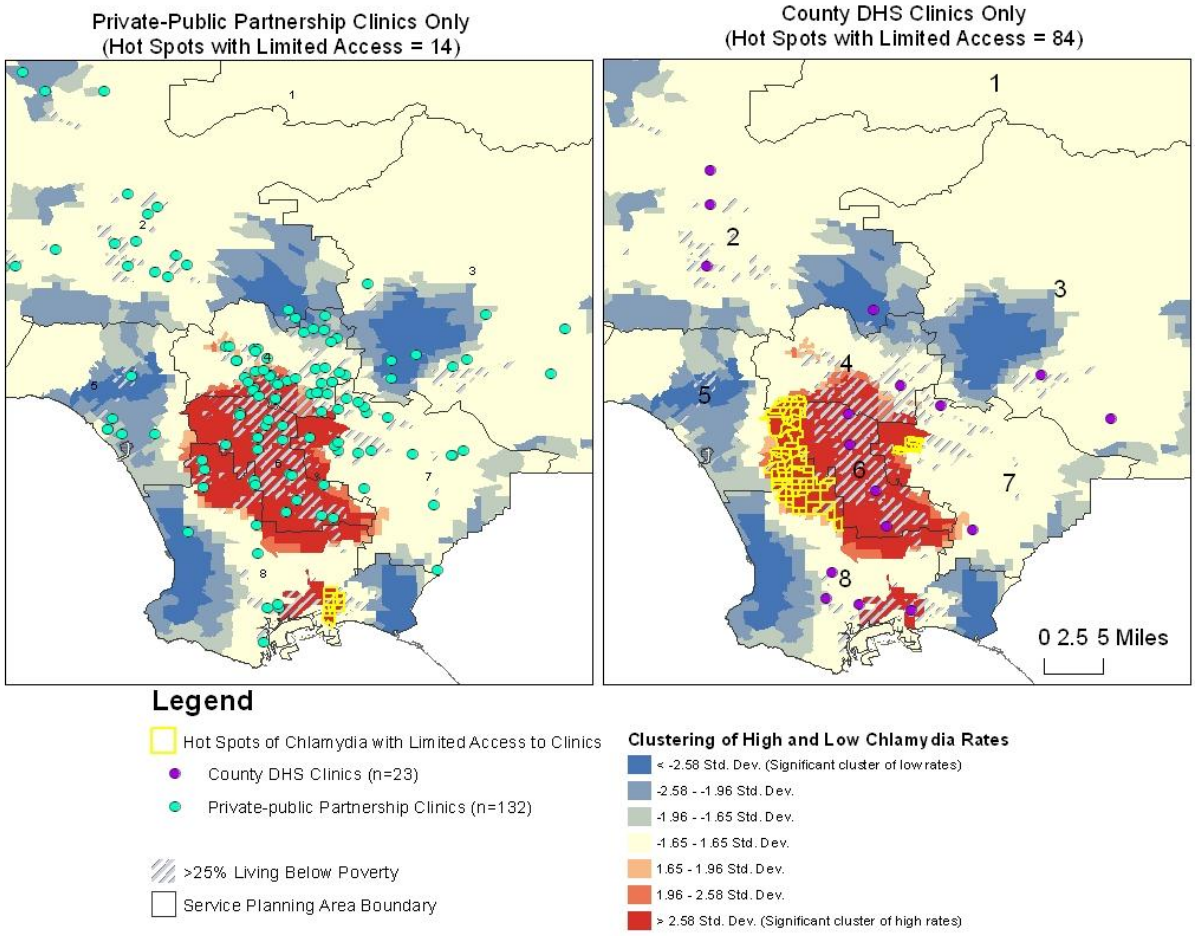

Table 4.3a Bivariate and Multivariate Associations between Chlamydia Hot Spots and Log-Distance to Clinic (OLS Regression Models with Robust Standard Errors)

	Bivariate	Model 1	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 hot spot	-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)*
R-Squared		0.39	0.43
AIC		4346.11	4201.70
Moran's I		P <0.001	P <0.001
Koenker Statistic		P <0.001	P <0.001

** p<0.001, * p<0.05

Table 4.3b Bivariate and Multivariate Associations between HPV-Related Cancer Hot Spots and Log- Distance to Clinic (OLS Regression Models with Robust Standard Errors)

	Bivariate	Model 1	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 hot spot	-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)*
R-Squared		0.38	0.43
AIC		4346.29	4202.85
Moran's I		P<0.001	P<0.001
Koenker Statistic		P<0.001	P<0.001

** p<0.001, * p<0.05

Table 4.4a Bivariate and Multivariate Associations between Chlamydia Hot Spots and Having a Clinic within 3 Miles (Logistic Regression with Robust Standard Errors)

	Bivariate	Model 1	Model 2
	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
Chlamydia hot spot	20.4 (8.38, 49.7)**	3.19 (1.23, 8.27)*	1.62 (0.52, 4.98)
% Living below poverty^	6.28 (4.82, 8.19)**	1.50 (1.09, 2.06)*	1.34 (1.02, 1.78)*
% Less than hs education^	6.59 (5.08, 8.56)**	3.84 (2.90, 5.09)**	1.40 (0.89, 2.22)
% No Vehicle^	6.41 (4.49, 9.17)**	2.11 (1.37, 3.24)**	1.95 (1.23, 3.11)**
% White^	0.34 (0.29, 0.41)**		1.0
% African American^	1.92 (1.51, 2.43)**		1.42 (1.15, 1.76)**
% Asian^	0.89 (0.81, 0.99)*		1.14 (0.97, 1.34)
% Latino^	4.36 (3.61, 5.27)**		2.03 (1.46, 2.82)**
% Non-Citizen^	5.09 (4.12, 6.28)**		1.47 (0.99, 2.19)
% Linguistically Isolated^	4.45 (3.42, 5.78)**		1.06 (0.72, 1.56)
Adjusted R-Squared		0.26	0.28
AIC		1414.19	1390.52

^ Standardized coefficients
** p<0.001, * p<0.05

Table 4.4b Bivariate and Multivariate Associations between HPV-Related Cancer Hot Spots and Having a Clinic within 3 Miles (Logistic Regression with Robust Standard Errors)

	Bivariate	Model 1	Model 2
	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
Cancer hot spot	3.60 (2.53, 5.15)**	1.32 (0.84, 2.06)	1.39 (0.86, 2.22)
% Living below poverty^	6.28 (4.82, 8.19)**	1.54 (1.13, 2.10)*	1.33 (1.00, 1.74)*
% Less than hs education^	6.59 (5.08, 8.56)**	4.12 (3.07, 5.53)**	1.47 (0.92, 2.33)
% No Vehicle^	6.41 (4.49, 9.17)**	2.04 (1.32, 3.17)**	1.87 (1.18, 2.97)*
% White^	0.34 (0.29, 0.41)**		1.0
% African American^	1.92 (1.51, 2.43)**		1.50 (1.27, 1.77)**
% Asian^	0.89 (0.81, 0.99)*		1.17 (0.98, 1.38)
% Latino^	4.36 (3.61, 5.27)**		2.08 (1.49, 2.90)**
% Non-Citizen^	5.09 (4.12, 6.28)**		1.45 (0.98, 2.16)
% Linguistically Isolated^	4.45 (3.42, 5.78)**		1.03 (0.70, 1.52)
R-Squared		0.25	0.28
AIC		1420.25	1389.17

^ Standardized coefficients
** p<0.001, * p<0.05

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Appendix 4.1 Los Angeles County Immunization Program Affiliated Clinics

SPA	Clinic Name
1	ANTELOPE VALLEY COMMUNITY CLINIC - LANCASTER
1	ANTELOPE VALLEY COMMUNITY CLINIC - PALMDALE
1	ANTELOPE VALLEY HEALTH CENTER
1	CARE-A-VAN MOBILE CLINIC
1	HIGH DESERT AMBULATORY CARE CENTER
1	LAKE LOS ANGELES COMMUNITY CLINIC
1	LITTLE ROCK COMMUNITY CLINIC
1	PALMDALE PRIMARY CARE
1	TARZANA TREATMENT CENTER
2	ALL FOR HEALTH, HEALTH FOR ALL, INC
2	COMPREHENSIVE COMMUNITY CLINIC - GLENDALE
2	COMPREHENSIVE COMMUNITY HEALTH CENTER
2	EL PROYECTO DEL BARRIO INC. - CANOGA PARK
2	EL PROYECTO DEL BARRIO INC./ARLETA
2	GLENDALE HEALTH CENTER
2	MISSION CITY COMMUNITY NETWORK
2	NORTHEAST VALLEY HEALTH CORP - SUN VALLEY
2	NORTHEAST VALLEY HEALTH CORP. - CANOGA PARK/EIS
2	NORTHEAST VALLEY HEALTH CORP. - EIS/PACOIMA
2	NORTHEAST VALLEY HEALTH CORP. - HOMELESS SHELTER
2	NORTHEAST VALLEY HEALTH CORP. - VALENCIA/EIS
2	NORTHEAST VALLEY HEALTH CORP. - VAN NUYS PEDIATRIC/ EIS
2	NORTHEAST VALLEY HEALTH CORP. -SF/EIS
2	OLIVE VIEW MEDICAL CENTER
2	PACOIMA HEALTH CENTER
2	SAMUEL DIXON FAMILY HEALTH CENTER
2	SAMUEL DIXON FAMILY HEALTH CENTER
2	SAMUEL DIXON FAMLY HEALTH CENTER
2	TARZANA TREATMENT CENTER
2	VALLEY CARE SAN FERNANDO HEALTH CENTER
2	VALLEY COMMUNITY CLINIC
3	ALTAMED – ESTRADA COURTS
3	ALTAMED – RAMONA GARDENS
3	ALTAMED – WILLIAMS MEDICAL
3	ALTAMED/EL MONTE COMMUNITY CLINIC
3	BIENVENIDOS COMMUNITY HEALTH CENTER
3	BIENVENIDOS HEALTH START COMMUNITY CLINIC

3	BUDDHIST TZU CHI FREE CLINIC
3	CLEAVER FAMILY WELLNESS CENTER
3	EAST VALLEY COMMUNITY - POMONA
3	EAST VALLEY COMMUNITY HEALTH DEPARTMENT - WEST COVINA
3	EL MONTE COMPREHENSIVE HEALTH CENTER
3	EL PROYECTO DEL BARRIO - AZUSA HEALTH CENTER
3	GARFIELD HEALTH CENTER
3	HERALD CHRISTIAN HEALTH CENTER
3	LA PUENTE HEALTH CENTER
3	MONROVIA HEALTH CENTER
3	PASADENA HEALTH DEPARTMENT
3	POMONA HEALTH CENTER
3	ST. FRANCIS MEDICAL CLINIC AT LYNWOOD
3	VALLEY-CARE MID VALLEY HEALTH CENTER
4	ALTAMED - GENERAL PEDIATRICS AT CHRLA
4	ANGELES COMPREHENSIVE COMMUNITY CLINIC INC.
4	ARROYO VISTA FAMILY HEALTH CENTER
4	ARROYO VISTA FAMILY HEALTH CENTER - EL SERENO
4	ARROYO VISTA FAMILY HEALTH CENTER - LOMA
4	ASIAN PACIFIC HEALTH CARE VENTURE INC.
4	CALIFORNIA FAMILY CARE - NECC
4	CHINATOWN SERVICES CENTER
4	CLINICA MSR. OSCAR A. ROMERO - ALVARADO
4	CLINICA MSR. OSCAR A. ROMERO - MARENGO
4	CLINICA MSR. OSCAR A. ROMERO - ST. VINCENT
4	COMPLETE CARE COMMUNITY HEALTH CENTER
4	COMPREHENSIVES COMMUNITY HEALTH CENTER - EAGLE ROCK
4	COMPREHENSIVES COMMUNITY HEALTH CENTER - HIGHLAND PARK
4	EISNER PEDIATRICS AND FAMILY
4	HOLLYWOOD SUNSET FREE CLINIC
4	HOLLYWOOD/WILSHIRE HEALTH CENTER
4	KHEIR HEALTH SERVICES CENTER
4	KORYO HEALTH FOUNDATION
4	LAC USC MEDICAL CENTER
4	LOS ANGELES CHRISTIAN HEALTH CENTER
4	LOS ANGELES FREE CLINIC
4	NORTHEAST COMMUNITY CLINIC - GRAND
4	NORTHEAST COMMUNITY CLINIC -HAWTHORNE
4	QUEENS CARE FAMILY CLINIC - BRESEE
4	QUEENS CARE FAMILY CLINIC - EAGLE ROCK

4	QUEENS CARE FAMILY CLINIC - ECHO PARK
4	QUEENS CARE FAMILY CLINIC - HOLLYWOOD
4	QUEENS CARE FAMILY CLINIC - WILSHIRE
4	SOUTH CENTRAL FAMILY HEALTH CENTER
4	ST. ANTHONY MEDICAL CLINIC - HOLLYWOOD
4	ST. ANTHONY MEDICAL CLINIC - PICO
4	ST. JOHN'S WELL CHILD AND FAMILY CENTER - WILLIAM
4	ST. JOHN'S WELL CHILD AND FAMILY CENTER -LINCOLN
4	THE SABAN FREE CLINIC - HOLLYWOOD
4	THE SABAN FREE CLINIC - MELROSE
4	UNITED AMERICAN INDIAN INVOLVEMENT, INC
4	UNIVERSAL HEALTH FOUNDATON
4	ST. FRANCIS CUDAHY
5	UCLA CHILDREN'S HEALTH CENTER
5	VENICE FAMILY CLINIC
5	VENICE FAMILY CLINIC - ROBERT LEVINE
5	VENICE FAMILY CLINIC - SIMMS MANN
5	VENICE FAMILY CLINIC - THE COLON FAMILY CLINIC
5	WESTSIDE WOMEN'S HEALTH CENTER
6	CENTRAL CITY COMMUNITY HEALTH CENTER
6	CENTRAL HEALTH CENTER
6	CLINICA PARA LA MUJERES - NECC
6	COMPTON CENTRAL HEALTH CLINIC
6	DOLLARHIDE HEALTH CENTER
6	FOSHAY CLINIC - NECC
6	H. CLAUDE HUDSON COMPREHENSIVE HEALTH CENTER
6	HUBERT H. HUMPHREY COMPREHENSIVE HEALTH CENTER
6	MLK AMBULATORY CARE CENTER
6	SOUTH CENTRAL FAMILY HEALTH CENTER - ACCELERATED SCHOOL
6	SOUTH HEALTH CENTER
6	ST. ANTHONY MEDICAL CLINIC - IMPERIAL
6	ST. JOHN'S WELL CHILD - EAST COMPTON
6	ST. JOHN'S WELL CHILD AND FAMILY CENTER
6	ST. JOHN'S WELL CHILD AND FAMILY CENTER
6	ST. JOHN'S WELL CHILD AND FAMILY CENTER - COMPTON
6	ST. JOHN'S WELL CHILD AND FAMILY CENTER - H.C.
6	T.H.E. CLINIC AT RUTH TEMPLE
6	UMMA FREE COMMUNITY CLINIC
6	WATTS HEALTH FOUNDATION
7	ALTAMED - BELL

7	ALTAMED – BOYLE HEIGHTS
7	ALTAMED – BOYLE HEIGHTS
7	ALTAMED - PICO RIVERA
7	ALTAMED MEDICAL GROUP - COMMERCE
7	ALTAMED MEDICAL GROUP - MONTEBELLO
7	AMERICAN INDIAN HEALING CENTER
7	BELL GARDENS FAMILY MEDICAL CENTER
7	BELLFLOWER HEALTH CENTER
7	COMMUNITY HEALTH ALLIANCE
7	EL PROYECTO DEL BARRIO - EAST LA SATELLITE CLINIC
7	HAWAIIAN GARDENS HEALTH CENTER
7	JWCH - BELL GARDENS HEALTH CENTER
7	JWCH - NORWALK HEALTH CENTER
7	KAMILA COMP HEALTH CENTER
7	PRESBYTERIAN INTERCOMMUNITY - CARE FORCE ONE
7	QUEENS CARE FAMILY CLINIC- EAST LOS ANGELES
7	ROYBAL COMPREHENSIVE HEALTH CENTER
7	ST. FRANCIS - COMPTON CLINIC
7	ST. FRANCIS - DOWNEY CLINIC
7	ST. FRANCIS MEDICAL CLINIC AT HUNTINGTON PARK
7	WHITTIER HEALTH CENTER
8	ARROYO VISTA - LINCOLN HEIGHTS
8	CURTIS R. TUCKER HEALTH CENTER
8	GLOBAL MEDICAL GROUP
8	HARBOR COMMUNITY CLINIC
8	HARBOR/UCLA MEDICAL CENTER
8	HARBOR-UCLA MEDICAL CENTER - FAMILY MEDICINE
8	LONG BEACH COMPREHENSIVE HEALTH CENTER
8	MARY HENRY TELEMEDICINE CENTER
8	MAYWOOD SENIOR HIGH SCHOOL
8	NORTHEAST COMMUNITY CLINIC
8	NORTHEAST COMMUNITY CLINIC -HAWTHORNE
8	SOUTH BAY FAMILY HEALTH CARE CENTER - INGLEWOOD
8	SOUTH BAY FAMILY HEALTH CARE CNTR - GARDENA
8	SOUTH BAY FAMILY HEALTH CARE CNTR - REDONDO BEACH
8	TORRANCE HEALTH CENTER
8	WILMINGTON COMMUNITY CLINIC
8	WILMINGTON FAMILY HEALTH CENTER

CHAPTER 5:

Conclusion of Dissertation Findings

5.1 Conclusion Overview

This dissertation explored the roles of geographic and neighborhood level factors on HPV vaccine access and uptake in Los Angeles County. Several methodologies, including geographic information systems (GIS) mapping techniques and clustered data analyses, were used to conduct three studies examining: (1) whether geographic access to safety-net immunization clinics is associated with HPV vaccine initiation among low-income, minority girls, (2) whether neighborhood level poverty and proportion of minority residents are associated with HPV vaccine initiation in the same sample of low-income, minority girls, and (3) if neighborhoods with increased cervical cancer risk have adequate geographic access to safety-net immunization clinics that provide HPV vaccination services.

This chapter summarizes the findings from the above three studies and discusses the limitations as well as the strengths of this research. The chapter concludes with a discussion on future research and policy implications related to HPV vaccination among underserved populations.

5.2 Geographic Access to Safety-Net Immunization Services in Los Angeles County

For the most part, HPV vaccination services via safety-net clinics are geographically accessible for low-income, ethnic minority girls and available in high-risk neighborhoods in Los Angeles County. Results from studies 1 and 3 revealed that a large majority of individuals and neighborhoods that would be expected to rely on safety-net vaccination services are located within 3 miles of a clinic affiliated with the Los Angeles County Immunization Program.

Specifically, study 1 revealed that 8 out of 10 girls in the sample live within 3 miles of a safety-net clinic and the average commute time by public transportation to the nearest clinic is 21 minutes. Similarly, study 3 revealed that 98% of neighborhoods with high Chlamydia rates and 94% of neighborhoods with high HPV-related cancer rates were location within 3 miles of safety-net HPV vaccination services. These results are reassuring and indicate that HPV vaccines at the county level are sufficiently geographically accessible to underserved populations that rely on safety-net services. These findings are not consistent with findings from prior studies that have showed proximity to health care providers as a significant barrier for receiving other preventive care services (Allard et. al., 2003; Elkin et. al., 2010; Fu et. al., 2009; McLafferty, 2003; Teach et. al., 2006).

Findings from study 3 also revealed that geographic coverage of services, especially for high-risk areas, are in large part contributed by private-public partnership clinics that are not directly operated by the LA County Department of Health Services. The contribution of private-public partnership clinics to the expansive geographic reach of the Los Angeles County safety-net system exemplifies the growing trend for public health systems to increasingly rely on collaborative networks for effectively reaching underserved populations (Mays et. al., 2010). These positive findings regarding the availability of services and geographic accessibility for target communities also suggests that future interventions may not need to focus largely on expanding services to a large portion of underserved communities. Because HPV vaccine uptake rates are low, however, future interventions should instead focus on system, provider, and community aspects that could improve the linkages between populations that could benefit most from HPV vaccines and geographically accessible clinics

5.3 Individual Level Predictors of HPV Vaccine Initiation

5.3.1 Geographic Access to Clinics

Results from this dissertation found that increased proximity to safety-net clinics was not significantly associated with increased vaccine uptake. There may be several reasons that explain these results. The primary reason could be that the substantial efforts by the county's public health immunization program, private-public partnerships, and other community resources are providing accessible immunization services throughout Los Angeles to adequately serve low-income communities as described above (Immunize-LA-Kids, 2008; LACDPH, 2011). Another possible explanation may be due to selection issues and participant heterogeneity. Mothers who called our hotline are presumably more motivated that mothers who do not use hotline services to seek health care services for themselves and their daughters. Perhaps these motivational factors also compress the variation in our sample. This implies that future research should test the hypothesis that intrinsic motivation may overcome geographic access barriers, and the corollary hypothesis that persons who are less motivated may be most severely affected by access barriers related to geography.

5.3.2 Awareness of HPV

Mother's awareness of human papillomavirus, age of adolescent girl, and having public insurance continued to be the strongest predictors for HPV vaccine initiation throughout the three studies. These results reinforce prior research showing that a large proportion of parents report needing more information about the vaccine as a reason for not having their daughter vaccinated (Bastani et al., 2011; Cates et al., 2009; Hughes et al., 2009; Yeganeh et al., 2010). Lack of information about HPV and the HPV vaccine among low-income mothers, rather than

concerns that the vaccine may cause increased sexual activity, has been reported as an important barrier to seeking the HPV vaccine for adolescent girls (Bastani et al, 2011; Guerry et al., 2011; Yeganeh et al., 2010). Many parents also believe their daughters are too young for the HPV vaccine, pointing to the need for adequate information about when the vaccine is most effective (Dempsey et al., 2009). These findings, supportive of current literature, suggest additional education about HPV vaccines as well as where to access the vaccines would be beneficial, even among mothers currently accessing county health services,

5.3.3 Health Care Coverage for Adolescent Immunizations

The study results also suggest health care coverage and clinical interactions with health care providers may be worth exploring in future research. Study 1 showed that girls with public health insurance had higher rates of initiation compared to those with both private and no insurance coverage. For low-income adolescent girls, having coverage from Medicaid or other public programs may be associated with having stronger ties to a usual source of care. Stronger ties to a medical home provides increased continuity of adolescent care, including vaccinations (Szilagyi et al., 2008), as well as a greater chance to receive a physician recommendation for vaccinations (Smith et al., 2005). In addition, county safety-net clinics have had a long-standing emphasis on preventing teen pregnancy and sexually transmitted infections. This preemptive focus on high-risk populations may increase the likelihood for girls who obtain care from these clinics to receive a recommendation for HPV vaccination or for their mothers to be provided information about the vaccine. Privately insured girls that obtain care at smaller physicians' offices, where adolescent health has not traditionally been an area of focus, may be less likely to be part of a health care system that is routinely focused on adolescent prevention services.

Lower rates of vaccine initiation among privately insured girls may also be reflective of the increasing cost-sharing and out-of-pocket costs for adolescent vaccines under private health insurance plans, thus leading to underinsurance among girls with private insurance (Smith et al., 2009). Prior studies show families at or near the poverty level are faced with disproportionate out-of-pocket costs that limit vaccine uptake (Molinari et al., 2007). In California, market factors related to capitation rates and lower reimbursement rates for adolescent vaccinations may dis-incentivize private providers from administering the HPV vaccine. Prior studies have shown that higher reimbursement rates for adolescent vaccines are significant predictors of vaccination and that opportunity costs are associated with the increased time it takes for providers to comply with all recommended vaccines within a well-visit (Fontanesi et al, 2001; Mclnerny et al, 2005). The recent elimination of out-of-pocket costs for all recommended immunizations under the Affordable Care Act will help to ameliorate the individual cost burden to low-income parents of adolescent girls in the future (U.S. Department of Health and Human Services, 2012), however, other market factors may continue to serve as barriers for providers to routinely provide the HPV vaccine for adolescent girls. Future research may want to focus particular attention on barriers to vaccination among larger samples of underinsured low-income girls with private coverage.

5.4 Communities that Could Benefit From Improved Geographic Access

Although it is reassuring that HPV vaccination services are largely geographically located near the residence of underserved adolescent girls and high-risk neighborhoods, some communities still face notable disadvantages in geographic access to safety-net clinics. Study 1 showed racial/ethnic differences in proximity of nearest clinic. This is consistent with a recent study showing that people in California with limited English proficiency faced greater

geographic barriers to safety-net clinics in general (Cordasco et. al., 2010). Despite the fact that the magnitude of differences for distance and time to nearest clinic across racial/ethnic groups observed in this study were small (i.e. estimated driving time for Latina girls was on average 3 minutes shorter than for Chinese girls), our measures for proximity to actual clinics may be underestimated for specific ethnic minority groups, including Chinese and Koreans that rely more heavily on clinics located within ethnically based community centers (Ngo-Metzger et. al., 2007; Traylor et. al., 2010). One possible indication for this is the inverse relationship we found between distance to nearest clinic and vaccine initiation among Chinese adolescent girls. The majority of Chinese adolescent girls resided in the San Gabriel Valley area of SPA 2. However, only a few clinics among the 155 safety-net clinics provide in-language services for Chinese speaking parents, and thus low-income, limited English proficient Chinese mothers may actually travel further to obtain the vaccine for their daughter. These findings support the need to better examine the relationship between proximity to health care and uptake of prevention services for specific ethnic communities as well as to understand that distance as a barrier may function differently for different communities as suggested by prior research (Koizumi et. al., 2009)

Study 3 also showed that a small number of census tracts with moderate to high rates of poverty and high cervical cancer risk had limited geographic access to clinics compared to other census tracts with similar risk. These census tracts with limited geographic access to safety-net clinics were located in SPAs 4 and 8 and were on the outer edges of the high-poverty areas located in the urban centers of Los Angeles County. A number of other high-risk neighborhoods that were not substantially socioeconomically disadvantaged were also further away from safety-net immunization services. While the majority of HPV vaccine-eligible girls in these comparatively wealthier neighborhoods may rely on private physicians' offices for immunization

services, low-income residents that do rely on safety-net clinics in these high-risk communities face additional geographic barriers (e.g. travel costs, travel time) to accessing the HPV vaccine. In a resource constrained environment, these findings are particularly useful for the county's public health program to expand services for needy low-income adolescent girls in a targeted fashion. A specific set of neighborhoods with limited geographic access to safety-net immunization services can be the primary areas of focus for county programs aimed to increase HPV vaccine uptake. Together, these findings from studies 1 and 3 contribute to the growing awareness that low-income populations living in moderately low-income areas may be at a greater disadvantage than low-income populations living in the poorest areas in accessing safety-net services (Blumenberg et. al., 2009; Kneebone et. al., 2011; Silver et. al., 2010).

5.5 Low-income Populations Living in Moderately Underserved Areas

Results from exploring the influence of neighborhood level poverty and neighborhood racial/ethnic composition on vaccine uptake further support the previous point on the need to focus on low-income populations living in moderately poor neighborhoods. Descriptive results showed that vaccination rates were much lower among low-income girls in neighborhoods with lower poverty rates (i.e. less disadvantaged neighborhoods) and lowest among low-income girls in neighborhoods with moderate poverty compared to girls in living in the poorest neighborhoods (i.e. most disadvantaged neighborhoods). Similar patterns were seen after comparing vaccination rates by the proportion of minority residents within each neighborhood.

The influence of neighborhood disadvantage on HPV vaccine initiation, however, did not remain significant after controlling for individual level factors. These non-significant findings may be indicative of characteristics related to this low-income sample described previously as

well as the small sample size to conduct fully clustered data analysis. As an initial exploratory analysis, these results suggest it may be important to further explore the lower rates of vaccination seen among girls in better off neighborhoods for purposes effective intervention development. For example, reasons for lower uptake rates among moderately disadvantaged neighborhoods may be similar to those described above for underinsured girls. Such as factors may include a greater reliance on private physicians' offices for immunization services, negative effects of low reimbursement rates on physician recommendations for adolescent vaccines (Bednarczyk and Birkhead, 2011; Young et al., 2011), and the increased geographic barriers in accessing safety-net clinics for suburban poor (Bednarczyk and Birkhead, 2011; Kneebone et al., 2011; Schootman et al., 2006; Silver et al., 2010; Young et al., 2011). Conversely, the higher rates of vaccination among girls in the poorest neighborhoods may be due to the increased exposure to HPV vaccination campaigns (LACDPH, 2011) and greater dependence on safety-net clinics where physicians are more likely to recommend routine vaccinations (Smith et al., 2005; Szilagyi et al., 2008). In addition, the higher rates of vaccination seen in the neighborhoods with the greatest minority residents also point to possible increased social networks and other aspects of social capital within ethnic enclaves that accelerate the dissemination of vaccine information (Kawachi and Berkman, 2000; Rogers, 2003).

5.6 Limitations of Study

There are some limitations that should be acknowledged in this research.

5.6.1 Study Sample

Studies 1 and 2 contain a convenience sample of low-income, ethnic minority mothers who called a women's health hotline in Los Angeles County. The study findings are likely

sensitive to selection bias if mothers in our study have higher self-motivation to seek health care compared to the general low-income population. Specifically, the magnitude of the effect of geographic access on HPV vaccine initiation may be underestimated in this study, as women who are more motivated in health seeking behavior may be willing to travel further for the health of their daughters. However, although these mothers are self-selected to the hotline, they call the hotline for the purposes of their own health and not to seek health care for their daughters or information regarding HPV. In addition, HPV vaccine initiation rates of daughters from this sample are substantially lower (29%) compared to rates reported by the CDC for low-income adolescent girls in California (51.9%) within the same time frame (CDC, 2011). This sample, though self-selected, is not necessarily a more advantaged low-income population in relation to HPV vaccination.

In addition to the potential selection bias of the study sample, the sample size (~ 490) of low-income adolescent girls is also relatively small and limits statistical power. The initial power calculations used to determine the optimal sample size for obtaining a minimally detectable difference in vaccine initiation between those who live within 3 miles of a clinic and those who live further than three miles were based on estimates from the literature as proxies. The parameters for the initial power calculations included effect sizes (Odds ratios of 1.7 and 2.0), distance estimates (3 miles) and proportion living within the distance estimate (25%). Given these estimates and the fixed sample of 490 vaccine-eligible girls, the power of the study ranged from 0.61-0.85. However, a much larger proportion of girls (>80%) lived within 3 miles of a clinic in our sample compared to the estimates obtained from the literature, resulting in the need for a much larger sample size to detect the same difference reported in other studies. Second, due to the limited clustering of adolescent girls within neighborhoods (average 1.4 girls per census

tract), the ability to conduct true multilevel analysis was limited. Furthermore, this sample came from a relatively small subset of neighborhoods (341 out of 2,054 census tracts in Los Angeles County) that did not have the same variability in socio-demographic factors compared to the county as a whole. Future studies that include a more generalizable sample of low-income girls may have different findings. Additional research of neighborhood level effects on HPV vaccine uptake would benefit from a larger sample size of low-income, minority girls.

5.6.2 Generalizability of Study Results

This sample of low-income, ethnic minority girls may not be representative of the broader low-income population in Los Angeles County or other urban areas. However, using this sample provides some insight to developing future policies and interventions for the neediest groups. Very little research has focused on low-income, minority populations at higher risk for cervical cancer that could benefit most from the HPV vaccine. This high-risk population is largely under-sampled in population-based datasets (e.g. California Health Interview Survey, Behavioral Risk Factor Surveillance Survey). Furthermore, the response rate for study participation among mothers with HPV vaccine eligible daughters was 93%. This suggests that while the sample may not be generalizable to low-income mothers elsewhere, it is quite representative of the Los Angeles County OWH hotline population. Findings from this study, therefore, can directly inform interventions that target the hotline population.

These research findings may also not generalize beyond Los Angeles County. As seen in study 3, the Los Angeles County safety-net system is fairly expansive and covers the areas of greatest need in terms of cervical cancer. Los Angeles County is the most populous county in the nation and has a public health system that is unmatched in size and scope by most other areas

(Saviano and Powers, 2005). The number of safety-net clinics alone (n=155) is larger than the number of clinics in many states as a whole. Other large urban areas with less developed safety-net systems or rural areas with health care provider shortages may see a substantial influence of geographic access on HPV vaccine initiation that was not observed in this dissertation research.

5.6.3 Spatial Analysis

In employing spatial analysis of proximity to safety-net immunization services among adolescent girls and high-risk neighborhoods there is an implicit assumption that the nearest clinic serves as the most likely place to obtain health care. Vaccinated girls in study 1 may not have received the HPV vaccine from the nearest safety-net immunization clinic to their residence, thus underestimating the relationship between geographic access and HPV vaccine initiation. Health services may be obtained at locations closer to a school or workplace. Some clinics with a further geographic distance from home could be selected based on clinic hours or language services. In addition, residents of neighborhoods in study 3 may not all rely on the nearest clinic to their census tract's geographic center. An individual's residence may be closer to a different clinic that the one closest to the neighborhood's center. Geographically larger census tracts are potential areas where nearest clinic for a neighborhood compared to an individual may be different. Furthermore, safety-net clinics, while comprehensive, may also not include all points of HPV vaccine access. While all safety-net immunization clinics included in the study were VFC providers, individual physicians may also apply for VFC program funding if they have eligible patients for the program. Some girls in the sample were privately insured and may rely on immunization services from private physicians' offices, however, our results showed

that these girls are less likely to receive the vaccine. This study was unable to capture the full universe of locations where girls in Los Angeles County may be able to obtain the HPV vaccine.

This research also used census tracts as neighborhood proxies. While 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 (Krieger et al., 2005). Little is known about whether definitions of neighborhoods differ by race/ethnicity (Diez Roux, 2001). Qualitatively defined neighborhood boundaries may be more suitable for low-income, ethnic minority populations. Some studies have shown that certain ethnic groups may rely on ethnic-specific health care organizations based on linguistic and cultural concordance factors (Gany et al., 2006; Ngo-Metzger et al., 2007; Yang and Kagawa-Singer, 2007). Other studies have also found that physical boundaries (e.g. highway, unused land space) often divide neighborhoods and prevent residents from using commercial areas or public parks across these geographical barriers despite the proximity to these resources (Maroko et al., 2009). Lastly, this study focused only on safety-net services in Los Angeles County and was, therefore, limited to geographic areas within county boundaries. For some individuals living near the county boundary, neighborhoods could encompass parts of adjacent counties. Furthermore, safety-net services from nearby Orange County may be more geographically accessible to an individual living on the county boundary line than the closest safety-net clinic within Los Angeles County. It was beyond the scope of this study to employ additional qualitative information that may determine neighborhood boundaries, but these issues are important to address in future research.

5.6.4 Response bias

Study results may also be biased due to the self-reported nature of HPV vaccination history from the parent HPV survey. HPV vaccine initiation rates may be underestimated if mothers did not disclose their daughter's immunization history due to perceived social stigma surrounding the vaccine. On the other hand, because mothers were reporting their daughters' immunization history to hotline operators who were part of the county health system, initiation rates may be overestimated due to the mothers' perception that hotline operators would want to hear that their daughters were vaccinated (i.e. social acceptability bias). Recent reports, however, show parental reporting of HPV vaccination had the highest validity in the National Immunization Survey compared to parental reporting of any other adolescent vaccines (Dorell et al., 2011).

Neighborhood level data were from the American Community Survey (ACS). The ACS is the U.S. Census Bureau's ongoing household survey that is conducted primarily by mail, but also followed by phone or in-person interviews after initial nonresponse to the mail survey (U.S. Census Bureau, 2008). The ACS has a high response rate of between 97-98% for the 2005-2009 survey years (U.S. Census Bureau, 2012). In addition, phone interviews are routinely provided in the following languages Spanish, Chinese, Russian, Korean, or Vietnamese (U.S. Census Bureau, 2007). As an ongoing household survey conducted to produce population-based estimates, the neighborhood level data are likely representative of the general population.

5.6.5 Causality

The cross sectional nature of this data limits the ability to identify causal relationships between geographic or neighborhood factors and vaccine uptake. The study employed

temporally aligned neighborhood level data by linking to the 2005-2009 American Community Survey rather than the 2000 Census data to the individual level data that was collected in 2009. However, studies 1 and 2 were unable to account for neighborhood tenure or residential mobility among adolescent girls and, therefore, cannot determine whether girls were living in neighborhoods long enough for exposure to geographic or neighborhood factors. Moreover, the individual level data on mothers' HPV awareness and daughters' vaccine uptake lacked a clear temporal relationship. In addition to issues of temporality, study 3 was subject to the ecologic fallacy. The ecological analysis in study 3 was unable to identify causal relationships between an individual's cervical cancer risk and geographic access to HPV vaccination services as the study focused on neighborhood level risk only and used geographic neighborhood centroids as a proxy measure for all residents within a census tract.

5.6.6. Omitted Variable Bias

Unmeasured individual characteristics, such as psychosocial factors related to HPV vaccine initiation, and neighborhood characteristics, such as uninsurance rates or cervical cancer screening, may be related to HPV vaccine initiation. Psychosocial factors, including perceived effectiveness of the vaccine or perceived benefits of immunizations in general, and other individual level factors related to HPV vaccine initiation are currently well published (Bastani et al., 2011; Gerend et al., 2009; Reiter et al., 2011; Robitz et al., 2011; Rosenthal et al., 2008; Tiro et al., 2011), including the primary study that collected the individual level data used in this dissertation research (Bastani et al., 2011). In addition, due to the limited sample size this study was underpowered to include psychosocial factors in the analysis. Given the importance of individual level influences on vaccination in addition to other contextual factor, future research

should examine additional influential variables on vaccine initiation. Subsequent studies may also want to explore other neighborhood factors as additional contextual influences on HPV vaccine initiation, including social capital or social cohesion (Kawachi and Berkman, 2000). This study used Chlamydia and HPV-related cancer rates as proxies for cervical cancer risk. While no routine HPV surveillance program exists for Los Angeles County, it may be more accurate to use a multifactor risk measure that incorporates both disease incidence and socio-demographic risk factors for cervical cancer. Lastly, this study used HPV vaccine initiation as the primary outcome variable. HPV vaccines encompasses three doses across six months and thus, using HPV vaccine completion as the outcome variable is more accurate in defining receipt of this new prevention strategy. The relationship between geographic access and HPV vaccine completion may be different for low-income populations, as the burden of travel time and costs to a clinic may serve as a significant barrier for underserved groups. Although we did not find a significant association between geographic access and vaccine initiation, it may be worthwhile for future studies to examine the relationship between proximity to clinics and vaccine completion.

5.6 Implications for Future Research

Results from the three studies showed that despite having geographically accessible immunization services in Los Angeles County, HPV vaccination is low among low-income, ethnic minority girls. Additional research is needed to identify: (1) if geographic access significantly influences vaccine completion or vaccine uptake for specific subgroups, (2) whether other clinic-based factors beyond geography (e.g. appointment times, in-language services) serve as barriers to accessing the HPV vaccine for minority and low-income populations, and (3)

effective interventions at the individual, physician, and organizational levels to promote increased HPV vaccine uptake.

This research focused on geographic access and HPV vaccine uptake among low-income, ethnic minority girls with mothers who use county health services. Although we did not find a significant relationship in this population, geographic access to HPV vaccination services may be a significant barrier for other populations. Low-income adolescent girls in other large urban areas may face geographic barriers to accessing HPV vaccination services. For example, other studies have shown that increased proximity to pediatric health services was linked to increased service use among urban, low-income populations (Fu et al., 2009; Teach et al., 2006). Geographic access to HPV vaccines is likely an even larger problem in rural areas. Thus, further research is needed to examine whether geographic barriers to vaccination services exist in other areas and among other populations. Furthermore, recent data from the National Immunization Survey revealed that while initiation rates were higher among girls living below poverty compared to those living above poverty in 2009, completion rates were significantly lower among low-income girls in 2010. Proximity to care may have a greater influence for HPV vaccine completion. Vaccine completion requires girls to return for the second and third dose within 2 and 6 months respectively after receiving the first dose. The time and costs required to travel to the same clinic three times within six months may be a significant barriers among low-income populations to completing the vaccine and these barriers may be more pronounced among girls that have to travel slightly further to their nearest safety-net clinic.

While safety-net clinics are geographically accessible to low-income, high-risk areas within the county, as seen in studies 1 and 3, further research is needed to differentiate between geographic access and other access issues related to clinic factors that facilitate HPV vaccination.

Following the definition of access used throughout the dissertation, Penchansky and Thomas defined access with five dimensions, including availability, accessibility, accommodation, affordability, and acceptability (Penchansky and Thomas, 1981). Clinic factors, such as availability of in-language services, clinic hours, ease in obtaining appointments, and scope of services, fall under the accommodation dimension of access and may serve as substantial facilitators or barriers for low-income, ethnic minority and largely limited English proficient mothers (Penchansky and Thomas, 1981). A study by Guerrero and colleagues found Latino-white disparities in provider-patient communication quality were likely linked to impeding provider recommendations and adherence to preventive services (Guerrero et al., 2010). Prior research has also shown that the availability for racially or linguistically concordant providers may be stronger than the influence of distance on service use (Ngo-Metzger et al., 2007). Other studies have shown that coupling HPV vaccination with other health care visits (e.g. teen well checks) provide additional windows of opportunity to increase vaccination rates (Tiro et al., 2011). Further research focusing on clinic-based operational factors may increase the current understanding of whether clinic-associated barriers exist in accessing the HPV vaccine among underserved populations.

Despite the proven effectiveness of HPV vaccines and the benefits for preventing future cases of cervical cancer, especially among populations with greatest risk, uptake is low compared to other recently available adolescent vaccines (CDC, 2011; Lindley et al., 2011). Findings from this research continue to support the need to increase awareness among mothers. In addition, other studies have pointed to the need to intervene on the physician side to increase recommendation of the vaccine (Kahn, 2007; Tissot et al., 2007). Recent studies have shown that vaccination reminder systems (Kharbanda et al., 2011) and combining HPV vaccination

with other clinic visits (Tiro et al., 2011; Vadaparampil et al., 2011) may be some effective strategies in promoting vaccine uptake. Given the complex social, political, and organizational issues around the 3-dose HPV vaccines, it is important that future research explore multilevel interventions targeted at all levels of influence (e.g. individual, physician, organizational) to most effectively increase vaccination rates (Fernandez et al., 2010).

5.7 Implications for Future Policies and Programs

Study results also point to programs that are needed to improve access to safety-net immunization services for some marginal geographic areas as well as policies that will improve access to the vaccine for low-income girls. First, results from study 3 indicated that a few high-risk neighborhoods in SPAs 4 and 8 could benefit from increased proximity to vaccination services. The Los Angeles County Department of Public Health's Immunization Program may want to: (1) partner with safety-net clinics to expand clinic outreach to surrounding neighborhoods and increase awareness about free HPV vaccination services, and (2) consider expanding immunization services (e.g. mobile immunization vans, opening school-based health clinics, etc) to the few high-risk neighborhoods identified in study 3 where geographic access to safety-net clinics are limited. It is important to note that geographic accessibility in this study was defined using a 3-mile distance threshold. The actual distance to the next closest clinic may be within 5 to 8 miles and thus the magnitude of proximity as a barrier may not be that significant. Sensitivity analyses from study 3 using a 5-mile radius resulted in no high risk areas lacking a nearby clinic. At the same time, however, given the unique geography, population density, and traffic in Los Angeles County, 3 to 5 miles to a nearest clinic could translate to 20-35 minutes of driving time in some areas. This length of time may in actuality serve as a

proximity barrier to services for low-income populations. Safety-net clinics located on the outer boundaries of the most impoverished areas in SPAs 4 and 6 may consider providing clinic outreach and expanding services to nearby moderately poor suburban areas where low-income adolescent girls may face additional barriers to accessing the vaccines.

Second, study results indicate that low-income girls with private insurance receive the HPV vaccine at lower rates compared to publicly insured girls. There are likely a variety of factors related to underinsurance and low physician reimbursement rates for adolescent vaccines that influence low vaccine uptake (Bednarczyk and Birkhead, 2011; Freed et al., 2009; Smith et al., 2009; Young et al., 2011). In September 2010, the Affordable Care Act (ACA) required that all insurance companies cover preventive health services, including vaccines recommended by the Advisory Committee for Immunization Practices (U.S. Department of Health and Human Services, 2012). These changes under the ACA will likely mitigate the financial burden of vaccine uptake for low-income girls. It is estimated that approximately 1,638,000 children received expanded preventive services coverage under this new ACA regulations (U.S. Dept. of Health and Human Services, 2012). However, it is not yet clear whether these additional costs to insurance providers will be passed along to patients through the form of increased premiums (Lavarreda et al., 2011). Further investigation of this potential negative effect along with the increasing costs of adolescent vaccines in general are warranted to develop future policies that protect low-income adolescent girls from having economic barriers to preventive services.

Aside from expanding preventive services coverage, the ACA's focus on medical homes may also increase the windows of opportunities to increase HPV vaccine uptake among adolescent girls. Prior studies have shown better adherence to recommended vaccinations among adolescents who report having a usual source of care (Smith et al., 2005; Szilagyi et al., 2008).

The increased emphasis on medical homes will likely increase the number of opportunities when vaccine-eligible girls can be vaccinated. The incentives to transition to electronic medical systems may also prompt safety-net clinics and other providers to be reminded to recommend the vaccine to age-appropriate patients.

Lastly, study findings have implications for current immunization programs delivered through the safety-net system. While clinics are geographically accessible to most populations, current immunization campaigns should focus on linking low-income adolescent girls to nearby clinics. Programs that target increasing awareness and knowledge about the vaccine among low-income, limited English proficient parents as well as physicians that primarily serve these communities are also warranted. It may be important for existing community vaccine promotion programs to collaborate with local safety-net clinics to expand outreach and increase focus on HPV vaccines. Given the logistical issues around delivering a 3-dose vaccine to an age group that has only recently received recommended preventive services, it is important for providers and clinics to develop systems that are effective and appropriate for enabling low-income adolescent girls to both initiate and complete the HPV vaccination series. Such systems may include offering the vaccine during other adolescent health visits, providing information about the vaccine to mothers who come to the clinics for their own health, and collaborating with local school-based health centers.

5.8 Conclusion

The HPV vaccine is a new preventive strategy that focuses on an age group outside the range of the population usually targeted for cancer prevention. Thus, HPV vaccination efforts rely on health care delivery programs outside of the traditional cancer prevention programs.

Without adequate uptake, it is unlikely that the vaccine will reach its potential to reduce cervical cancer burden among all populations, thereby causing disparities to remain. Study findings suggest that while services are available to underserved populations, HPV vaccine uptake is unacceptably low. Future research should focus on individual, physician, and organizational strategies to increase vaccine uptake, especially in relation to high-risk populations. ACA implementation to remove out-of-pockets costs may help to reduce the barriers to vaccination for underinsured and low-income girls in the future.

This research identified available safety-net immunizations services for low-income populations in Los Angeles County and specific geographical areas that may benefit from increased geographic access to safety-net services for HPV vaccination using GIS mapping and a combination of individual and neighborhood level data. These approaches can be applied to other novel chronic disease prevention strategies that become available in the future to evaluate the accessibility of new preventive services. Furthermore, this research provides actionable information for local cancer prevention and control programs to develop effective interventions that are specific to populations that can benefit most of the HPV vaccines.

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