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HPV Vaccination Coverage Among US Teens Across the Rural-Urban Continuum

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Abstract

Background: In this study, we used data from the National Immunization Survey-Teen (NIS-Teen) to examine HPV vaccination uptake by rural and urban residence defined by ZIP Code.

Methods: 2012-2013 NIS-Teen data were used to examine associations of HPV vaccination among teens aged 13-17 years with ZIP Code measures of rural/urban (Rural-Urban Commuting Area (RUCA) codes, population density). Multivariable logistic regression was used to estimate the odds of HPV vaccination initiation (≥ 1 dose) and completion (≥ 3 doses).

Results: HPV vaccination was lower among girls from isolated small rural towns (≥1 dose 51.0%; ≥3 doses 30.0%) and small rural towns (≥1 dose 50.2%; ≥3 doses 26.8%) than among urban girls (≥1 dose 56.0%; ≥3 doses 35.9%). Girls from small rural towns had lower odds of completion (0.74, 95% CI: 0.60-0.91) than girls from urban areas. HPV vaccination was lower among boys from isolated small rural towns (≥1 dose 17.3%; ≥3 doses 5.31%) and small rural towns (≥1 dose 18.7%; ≥3 doses 5.50%) than those in urban areas (≥1 dose 28.7%; ≥3 doses 10.7%). Boys in isolated small rural towns had statistically significantly lower odds of initiation (0.68, 95% CI: 0.52-0.88) and completion (0.63, 95% CI: 0.41-0.97) than urban boys. Girls and boys from high-poverty rural areas had lower odds of initiation and completion than did their counterparts from high-poverty urban areas.

Conclusion: Rural girls had lower odds of completing the HPV vaccine than their urban counterparts. Rural boys had lower odds than urban boys for HPV vaccination initiation and completion.

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Keywords

health care disparities; human papilloma virus; human papilloma virus vaccines; preventive health; rural health

The human papillomavirus (HPV) is a risk factor for cervical, vulvar, vaginal, penile, anal, and oropharyngeal cancer.[1] Incidence in HPV-related cancers has increased in recent years among men and women in the United States,[1] with a disproportionate increase in rural areas.[2] The HPV vaccine can prevent many of these cancers. The Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) has recommended the HPV vaccine for girls aged 11–12 since 2006 and boys aged 11–12 since 2011.[3,4] Prior to October 2016, the HPV vaccine was administered in 3 doses over 6 months via intramuscular injection. The ACIP now recommends 2 doses be given over a 6-month period for children under age 15.[5,6] Despite the availability of a vaccine that is safe and effective long term in protecting against HPV[7] that can cause multiple forms of cancer, the number of HPV-immunized people is significantly lower than CDC goals. The Healthy People 2020 target for HPV vaccination completion among teens aged 13–15 years is 80%.[8] More than a decade after the vaccine was recommended for girls and 5 years after its recommendation for boys, 5 out of 10 girls and 6 out of 10 boys have not met this target.[9]

Studies aimed at assessing the reasons for low HPV vaccination coverage suggest that multiple factors play a role.[8,9] The lack of parental knowledge, health care provider recommendations, missed opportunities, infrequent primary care visits by adolescents, religious and cultural influences, and hesitancy to vaccinate adolescents against a sexually transmitted infection are factors that contribute to HPV vaccine coverage.[10] Furthermore, failure to return for the remaining doses has led to low rates of series completion.

Research also suggests that geographic and area-based factors are associated with vaccine uptake. While wealthy areas commonly have higher rates of cancer prevention and screening among adults, HPV vaccination uptake is higher for poorer girls and boys than for those living in wealthy areas.[11,12] Additionally, studies consistently report that urban teens have higher rates of HPV vaccine coverage than their rural peers, with 50.4% of rural adolescents living outside a Metropolitan Statistical Area (MSA) initiating the HPV vaccine, compared to 65.9% of urban adolescents living in MSA central-city areas.[13,14]

While there is a general consistency in previous studies that teens living in rural places have lower HPV vaccination rates compared to those living in urban places, most of the previous studies are based on various definitions of urban and rural places that are delineated by large heterogeneous geographies, such as counties.[14,15] Most of the previous studies, particularly those using the Behavioral Risk Factor Surveillance System (BRFSS) or NIS-Teen data, define urban and rural places based on county-level classifications developed by the Office of Management and Budget (OMB).[16] In technical documentation, the OMB states that “the Metropolitan and Micropolitan Statistical Area Standards do not equate to an urban–rural classification; many counties included in Metropolitan and Micropolitan Statistical Areas, and many other counties, contain both urban and rural territory and populations.”[16] Using large areas to define what is urban and rural could result in misclassification and errors in measuring vaccination differences between these places. This reinforces the need to examine HPV vaccination coverage across the rural-urban continuum using more granular data than county.

In this study, we analyzed data from NIS-Teen to examine associations between HPV vaccination uptake and rural and urban residence measured at the ZIP Code level. We also examined whether vaccine uptake in rural and urban places was modified by area-based poverty. To our knowledge, this study is among the first studies to examine the relationship between HPV vaccine initiation and 3-dose completion for teens by urban and rural residence for the entire US using data that are more granular than county-level data.

Materials and Methods

Study Design

We analyzed the restricted-use data of the NIS-Teen, a yearly survey managed by the CDC to track vaccination levels throughout the US. The NIS-Teen includes data on adolescents aged 13–17 from all 50 states plus the District of Columbia, and it is a stratified sample that represents data from across the US. It uses a random-digit-dialed sample with both landline and cellular telephones, and the survey respondents are the teens' parents or guardians who provide sociodemographic and vaccination-related information for their children and relevant health care providers. Parents consented to the provider verifying the teen's vaccination records with the survey team.

We examined data from the 2012 and 2013 NIS-Teen. The dataset included a total of 34,931 boys and 31,843 girls with completed surveys. Of the teens in the survey, 20,355 (58.2%) boys and 18,350 girls (57.6%) had provider-verified vaccination records. Approximately 4% of the provider-verified records were excluded because of missing ZIP Codes (0.5%) or values (3.5%). There was no evidence of differences between survey participants included and excluded in the study by any of the individual-level or ZIP Code Tabulation Area (ZCTA) geographic measures. The final analytic dataset consisted of 17,596 girls and 19,518 boys with provider-verified vaccination data.

Measures

Individual Level—Two HPV vaccination outcomes were examined: 1) initiation—receipt of at least 1 dose of the HPV vaccine; and 2) completion—receipt of 3 doses of HPV vaccine (prior to 2016 the vaccine was delivered in 3 doses). Individual-level and sociodemographic characteristics shown to be associated with HPV vaccination initiation and completion were included in the statistical models: teen's age in years; race/ethnicity (non-Hispanic white; non-Hispanic black; Hispanic; and others); health insurance coverage (employer or union; Medicaid or the State Children's Health Insurance Program; military or Indian Health Service; and no health insurance); household income/poverty (high income [annual income >$75,000]; moderate income [annual income ≤$75,000]; below poverty, calculated from Census poverty thresholds[17]; and unknown poverty status); mother's age (≤34 years; 35–44; or ≥45); and mother's highest level in school (<12 years; 12 years with high school diploma or general equivalency diploma; >12 years with no college degree; or college degree or higher). In addition, we included the facility type reported by providers of where vaccines were administered as a health care system factor (all private facilities; all public facilities; all hospital facilities; all STD/school/teen clinics or other facilities; mixed facilities; and unknown).

Rural and Urban Measures—We used the 2010 Rural-Urban Commuting Area (RUCA) codes to define urban and rural places at the ZCTA level.[18–20] RUCA codes classify census tracts based on measures of population density, urbanization, and daily commuting flows. RUCA codes summarized by ZCTAs are assigned from census tracts using a geographic intersection procedure that was completed by the WWAMI Rural Health Research Center.[21] There are 33 RUCA codes that can be aggregated in different ways to delineate metropolitan, micropolitan, small town, and rural areas. We aggregated RUCA codes into 2 separate categorizations: 1) urban focused [1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1,10.1], large rural city/town focused [4.0, 4.2, 5.0, 5.2, 6.0, 6.1], small rural town focused [7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2], and isolated small rural town focused [10.0, 10.2, 10.3, 10.4, 10.5, 10.6]; and 2) urban and rural. The binary urban/rural categorization is based on the aggregation of the 3 rural categories into 1 category.[18] These 2 categorizations are defined on the WWAMI Rural Health Research Center website and have been used regularly in health research. The WWAMI Rural Health Research Center website states that "the advantage of this definition is that it splits urban and rural in approximately the same way as does the OMB Metro definition but at the sub-county level, and it divides rural into three relevant and useful categories."[22]

Using the 2008–2012 US Census American Community Survey, we developed 2 additional ZCTA-based socioeconomic and geographical contextual measures.[18] The percentage of the population living below the poverty line was developed to assess area-based socioeconomic deprivation. Area-based socioeconomic measures, such as poverty, describe a geographic area (eg, ZCTA, tract) in which a person lives that could impact access to health care and resources.[23,24] An area measure such as poverty has shown to be independently associated with various health outcomes.[25,26] Poverty was grouped according to the percentage of the total population living below the federally defined poverty threshold in the ZCTA: <.05%, 5.0%−9.9%, 10.0%−19.9%, and >20.0%.

We also included population density (defined as total population divided by area) by ZCTA. Population density has been used to indicate urban-rural residence,[28,29] crowding,[27] and the built environment.[28] Furthermore, unlike RUCA and census measures of rural/urban that are available only every decade and created from the decennial census, population density is available continuously in the American Community Survey. Using population density provides flexibility when measuring trends in outcomes between decennial censuses. For this study, we divided population density into quartiles based on the nationwide distribution of the population density values (Q1 1–20, Q2 21–71, Q3 72–651, Q4 >651 people per square mile).

Statistical Analysis

We combined NIS-Teen data for 2012 and 2013 using suggested methods and applied provider-verified sampling weights to estimate percentages and effect estimates.[29] We performed bivariate association tests for variables and the primary outcomes with Wald chi-square tests. Weighted multivariable logistic regression was used to identify geographic variables associated with the primary outcomes.

The multivariable models produced adjusted odds ratios (AORs) and 95% confidence intervals (CIs). For each outcome, we estimated 3 separate multivariable models that included all the individual-level variables, the 2 provider factors, ZCTA poverty, plus 1 of 3 urban–rural measures developed for this study (RUCA 4 category, RUCA 2 category, population density). Joint contributions of ZCTA poverty and urban and rural were assessed with interaction terms. Models also included the participants' state of residence as a random effect to adjust for homogeneity by state (eg, state-based programs that might affect HPV vaccination from that state).

Bivariate associations between HPV vaccine outcomes and independent variables were examined using SAS 9.3 Proc SurveyFreq.[30] Models were estimated using generalized linear models (SAS 9.3 PROC GLIMMIX).[31] Dichotomous outcomes (initiation, completion) were estimated assuming a binomial distribution with a logit link (eg, logistic regression). Models accounted for the survey stratum and weights. The results for the individual-level variables were previously published[32,33]; therefore, in this manuscript the tables/figures include only the geographic variables.

Results

A total of 17,596 girls and 19,518 boys, 13–17 years of age, had adequate provider data in the 2012–2013 NIS-Teen and were included in the study (Tables 1 and 2).

Girls

In 2012–2013, 55.6% of girls initiated and 35.3% completed the vaccine. Approximately 26.1% of girls in the study population lived in the poorest ZIP Codes (20% or more residents living below the poverty line), while 12.8% lived in the least impoverished areas (0%−4.99% living below the poverty line). Sixty-one percent of girls living in the poorest ZIP Codes and 54.8% of girls living in the least impoverished ZIP Codes initiated the vaccine. Most girls in the study population lived in urban areas (89.1%) and in places with population densities more than 651 people per square mile (quartile 4; 60.3%).

Based on the chi square tests, ZCTA poverty was associated with HPV vaccine initiation but not completion (Table 1). After combining rural towns into one grouping, we found rural and urban residencies were associated with vaccine completion: 35.9% of urban girls, 31.2% of rural girls, 30.0% of girls in isolated small rural towns, and 35.9% of girls in urban-focused areas completed the vaccine series.

While other measures of rural residence were significant only for vaccine completion, population density was significantly associated with both initiation and completion. The least populous areas (1–20 per square mile) had the least vaccine initiation (48.3%) and completion (26.1%), while the most populous areas (>651 per square mile) had the most initiation (57.1%) and completion (36.6%).

Figure 1 summarizes the AORs from the multivariable logistic regression models and the bivariate (crude) ORs. In both the bivariate (crude ORs) and multivariable analyses that included individual-level factors, provider factors, and ZCTA poverty, none of the RUCA urban–rural measures were associated with HPV vaccination initiation. The crude odds were significantly lower for girls from isolated small rural towns, small towns, and the combined rural category, compared to girls from urban areas for vaccine completion. However, the only variable that remained statistically significant in the multivariable analyses was small rural towns.

The adjusted odds of completion among girls from small rural towns were lower (AOR 0.74, 95% CI: 0.60–0.91) than for girls living in urban areas. In addition, girls from the least population-dense areas had statistically significantly lower odds of HPV vaccination initiation (AOR 0.81, 95% CI: 0.67–0.99) and completion (AOR 0.74, 95% CI: 0.60–0.91) than their counterparts living in the densest areas.

The interaction terms—ZCTA poverty and urban–rural residence—were statistically significant for both HPV vaccination initiation and completion. Poorer girls from rural areas had lower odds of initiation (AOR 0.79, 95% CI: 0.65–0.94) and completion (AOR 0.72, 95% CI: 0.59–0.88) than did their urban poor counterparts. Comparisons between the girls living in the poorest versus wealthiest rural areas indicated no significant differences for both outcomes, and this was also true for the poorest urban areas when compared to the richest urban areas. However, girls from the highest poverty category (>20%) living in rural areas indicated lower odds of both initiation (AOR 0.72, 95% CI: 0.53–0.99) and completion (AOR 0.69, 95% CI: 0.49–0.96) compared to girls from the second-lowest poverty category (5.00%−9.99%) living in rural areas. Figure 2 summarizes the model-adjusted percentage of girls who initiated HPV vaccination and completed the series based on the interaction.

Boys

The characteristics of the study population and results for the bivariate analysis of ZCTA variables for boys are presented in Table 2. Among the boys, 27.9% initiated the vaccine, and 10.4% received 3 or more doses of the vaccine in 2012–2013. Approximately 24.9% of boys lived in the poorest ZIP Codes, while 13.5% lived in the least impoverished areas. Based on a chi square test, ZCTA poverty was associated with vaccine initiation and completion. We found that 34.8% of boys from the most impoverished ZIP Codes and 24.4% of boys in the least impoverished ZIP Codes initiated the vaccine, while 12.9% of boys from the most impoverished ZIP Codes and 9.01% from the least impoverished ZIP Codes completed the series.

Most boys in the study population (89.0%) lived in urban areas and places with population densities of 651 or more persons per square mile. Based on a chi square test (Table 2), residence type defined by RUCA codes was statistically significantly associated with both vaccine initiation and completion. More boys in urban areas initiated (28.7%) and completed

(10.7%) the vaccine than did boys in isolated small rural towns (17.3% initiated and 5.31% completed). After combining the rural variables into 1 variable, urban boys still initiated (28.7% vs. 18.3%) and completed (10.6% vs. 5.95%) the vaccine more than rural boys did. In addition, 19.3% of boys initiated the vaccine in the least dense areas, compared to 31.2% in the most population dense areas. Similarly, fewer boys in less dense areas (8.10%) completed the vaccine than did boys in more dense areas (11.4%).

Figure 1 summarizes the AORs from the multivariable logistic regression models and the bivariate (crude) ORs. In both bivariate and multivariable analyses that included individual-level factors, provider factors, and ZCTA poverty, RUCA-based urban and rural measures were significant in boys for both vaccine initiation and completion. We found that boys living in large rural towns (AOR 0.67, 95% CI: 0.57–0.79), small rural towns (AOR 0.67, 95% CI: 0.54–0.84), and isolated small rural towns (AOR 0.68, 95% CI: 0.52–0.88) had lower odds of HPV vaccine initiation and completion, compared to boys living in urban places (Figure 1). After collapsing the 3 levels of rural towns, RUCA urban and rural measures were still significant for both initiation and completion. The odds of initiation and completion among boys from rural areas were 0.67 (95% CI: 0.59–0.77) and 0.66 (95% CI: 0.54–0.80) times lower, respectively, than for boys in urban areas.

The interaction terms—ZCTA poverty and urban–rural residence—were statistically significant for both initiation and completion. Boys from rural areas with the highest rates of poverty had lower odds of initiation (AOR 0.61, 95% CI: 0.49–0.75) and completion (AOR 0.36, 95% CI: 0.24–0.53) than did their urban poor counterparts. Comparisons between the boys living in the poorest versus wealthiest rural areas indicated no significant differences for both outcomes, and this was similar for the poorest urban areas compared to richest urban areas for initiation. However, boys from poor urban areas had higher odds (AOR 1.26, 95% CI: 1.04–1.52) of HPV vaccination completion than boys from wealthy urban areas had. The model-adjusted percentage of boys who initiated HPV vaccination and completed the series is summarized in Figure 2.

Discussion

The goal of this study was to examine associations between HPV vaccination uptake and rural and urban residence and poverty measured at the ZIP Code level. We found that while rural girls complete the HPV vaccine less often than urban girls, after controlling for individual, provider, and ZCTA poverty factors, this association was no longer significant. In contrast, after controlling for these factors in boys, rural boys continued to have lower odds of both vaccine completion and initiation than urban boys had.

Rural residents face distinctive challenges, such as travel distance, transportation problems, and inability to take time off from work, to accessing preventive health care. Also, the limited provider networks within rural areas[20] may negatively affect using preventive health services, particularly for services identified with sexual activity.[34] As the HPV vaccine required 3 doses up until 2016, barriers to returning to the clinic multiple times could be at play in rural areas where transit times are longer and there are fewer available modes of transportation than in urban areas. This could explain why rural boys and girls are not completing the vaccine series as often as those living in urban areas. With the recently reduced dose recommendation, completion rates for both sexes could be improved since they will make fewer trips to the doctor.

Additionally, some research has reported specific cultural values, such as fatalism, within rural populations that can challenge health care delivery in those settings.[35,36] Rural individuals generally have been shown to have lower incomes,[37] less educational attainment,[36] and higher rates of being uninsured than their urban counterparts,[38] which may be associated with poorer health literacy and disparate health outcomes in rural areas.[37,39] Regarding health literacy specific to HPV, Mohammed and associates found that rural residents have less knowledge and awareness of HPV and the HPV vaccine, including less awareness of HPV causing cervical cancer.[40] These factors may affect rural residents' acceptance of new vaccine recommendations and vaccine completion.

Interestingly, there seems to be less difference in childhood vaccination rates for the tetanus, diphtheria, and pertussis (Tdap) and the influenza vaccines between rural and urban children. This is in spite of Tdap being required for school attendance in all states but Hawaii, while influenza is not required in most states.[41] For the meningococcal ACWY vaccine, however, there was a difference between rural and urban areas, even though it is required in 30 states plus the District of Columbia.[42–44] While the Walker and colleagues 2017 study[42] showed differences in rural–urban vaccination coverage, their data were based on county-level measures rather than ZIP-Code-level measures as this study has used. More evaluation is needed at the ZIP Code level or smaller geographies (eg, census tract) to determine if this geographic difference exists between mandatory vaccines. A study examining HPV vaccination in the Intermountain West region found that receipt of the Tdap, influenza, or meningitis vaccine was associated with an increased prevalence of receiving the HPV vaccine.[45] This could be due to parental acceptance of vaccines generally or provider recommendation leading to acceptance of the HPV vaccine. Additionally, as there are fewer pediatricians in rural areas, adolescents may be seeking care from providers not as familiar with vaccine recommendations, and thus not receiving multiple recommended vaccines.[46] The differences in coverage among other vaccines that the CDC has recommended for all children longer than the HPV vaccine could indicate that recommendation implementation differences are due less to novelty of the recommendation and more to geographical variations in attitude and culture, or a combined effect of health literacy, access to care, and education.

A possible explanation for our findings of lower HPV vaccination in rural areas is that fewer rural teens might have received a provider recommendation for their first HPV vaccination dose than urban teens. A post-hoc examination of our sample indicated that in fact the proportion of teen girls (56.7% 95% CI: 53.5–60.0) and boys (27.7 95% CI: 25.1–30.2) in rural areas with a provider recommendation was lower overall than teen girls (64.1% 95% CI: 62.6–65.6) and boys (36.0 95% CI: 34.6–37.4) in urban areas. Further research is needed to examine the differences in provider recommendations in rural versus urban areas at the ZIP Code level.

As HPV is a sexually transmitted infection, differences in attitudes about sexual activity between rural and urban parents could explain differences in vaccination. With regard to attitudes about sexual activity, fear of sexual disinhibition has been touted as a reason for parents to refuse the vaccine.[47] One study found that parents who self-identify as politically conservative are more likely to believe that the HPV vaccine will lead to increased sexual activity in their daughters.[48] As more rural areas tend to be more politically conservative, a concern about sexual disinhibition could explain differences in vaccination rates.[49]

Of note, population density was significantly associated with vaccine initiation and completion for boys and girls, which persisted in multivariable analyses even after controlling for poverty. We are unsure why boys and girls living in the most densely populated areas were most likely to initiate and complete the vaccine; however, this finding provides further support of rural–urban disparities in HPV vaccination.

In examining the interaction between poverty and rural and urban areas, the results indicated that boys and girls living in poor rural areas had lower odds of vaccine initiation and completion than their counterparts living in poor urban areas had, suggesting that residence rather than poverty alone may be more important in vaccination compliance. Urban areas often have more community health centers and vaccine programs that target low-income populations, as well as public transit systems that provide low-income residents cost-effective and time-efficient modes of accessing health care, which rural areas lack.

Limitations and Strengths

This study has several limitations. First, the overall household response rate for 2012 and 2013 combined was approximately 36.7% (53.5% for the landline and 23.7% for the cell phone samples), and only 61.1% of landline-completed and 55.1% of cellphone-completed interviews had adequate provider data verifying vaccination. Because non-responders might have answered the survey differently than responders, the NIS-Teen survey is adjusted for household and provider nonresponse and phoneless households. Despite survey adjustments and sample weighting to minimize nonresponse and non-coverage, bias in estimates might remain. Second, provider nonresponse is accounted for in the sampling weights. However, the use of provider-verified immunization records may have led to an underestimation of vaccination coverage, as these records from providers may have been incomplete. We also do not know whether certain types of facilities might be more likely to keep more complete records or whether this might vary in urban versus rural areas. We did, however, examine whether there were differences in the distribution of records with and without adequate provider data by rural/urban, population density, area poverty, and facility type. No differences were noted between survey participants with and without provider-verified vaccine reports for ZCTA poverty or facility type. Differences were noted for rural/urban residence, but the survey data showed that the proportion of teens with adequate provider data was higher among participants in rural areas compared to urban (rural girls 59.5%, 95% CI: 57.0–61.9 to urban girls 56.8%, 95% CI: 55.7–57.9 and rural boys 63.7%, 95% CI: 61.4–65.9 to urban boys 58.1%, 95% CI: 57.0–59.1). Third, this study examines 2 years of data, 2012 and 2013, just as the recommendation to vaccinate boys went live in 2011. While this study captures the early trends that could be applied to future new vaccination programs, it does not expand on the trend over time as the recommendation becomes more widely adopted. Finally, while the NIS-Teen survey data are available publicly, the ZIP Codes are restricted variables; therefore, adding additional years of data was limited by data access restrictions for the study protocol approved by the Research Data Center. Despite these limitations, the strengths of this study include the use of provider-verified HPV vaccination data from the largest nationally representative sample of teens in the US and the use of participant ZIP Codes, a restricted NIS-Teen variable, to assess HPV vaccination uptake among teens living in urban and rural places.

Conclusion

In conclusion, rurality was a significant factor in teens' initiation and completion of the HPV vaccine, particularly for boys, which may be exacerbated by poverty. This study provides the foundation for targeted interventions for both urban and rural teens and highlights the need to improve access to health care programs for poor and rural adolescents in the US. More research is necessary to better understand the factors contributing to the lower HPV vaccination rates in rural areas and to identify interventions to increase rates.

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References

1. Viens LJ, Henley SJ, Watson M, et al. Human Papillomavirus-Associated Cancers - United States, 2008–2012. MMWR Morb Mortal Wkly Rep. 2016;65(26):661–666. [PubMed: 27387669]
2. Zahnd WE, James AS, Jenkins WD, et al. Rural-Urban Differences in Cancer Incidence and Trends in the United States. Cancer Epidemiol Biomarkers Prev. 2018; 27(11):1265–1274. [PubMed: 28751476]
3. Kuehn BM. CDC panel backs routine HPV vaccination. JAMA. 2006;296(6):640–641. [PubMed: 16896097]
4. Markowitz LE, Dunne EF, Saraiya M, et al. Human papillomavirus vaccination: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep. 2014;63(RR-05):1–30.
5. CDC. "HPV Vaccine Information for Clinicians - Fact Sheet." Centers for Disease Control and Prevention Available at: http://www.cdc.gov/std/hpv/stdfact-hpv-vaccine-hcp.htm. Accessed July 7, 2016.
6. Meites E, Kempe A, Markowitz LE. Use of a 2-Dose Schedule for Human Papillomavirus Vaccination - Updated Recommendations of the Advisory Committee on Immunization Practices. MMWR Morb Mortal Wkly Rep. 2016;65(49):1405–1408. [PubMed: 27977643]
7. Akinsanya-Beysolow I, Jenkins R, Meissner HC. Advisory Committee on Immunization Practices (ACIP) recommended immunization schedule for persons aged 0 through 18 years--United States, 2013. MMWR Suppl. 2013;62(1):2–8. [PubMed: 23364302]
8. U.S. Department of Health and Human Services. Healthy People 2020: immunization and infectious diseases objectives. [Internet].Washington, DC: DHHS; 2013 [updated 2013 Apr 24; cited 2016 Jul 1]. Available from: http://www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicId=23.
9. Centers for Disease Control and Prevention. Teen Vacciantion Coverage. 2015 National Immunization Survey (NIS)-Teen 2015; https://www.cdc.gov/vaccines/imz-managers/coverage/nis/teen/index.html. Accessed October 22, 2018.

10. Holman DM, Benard V, Roland KB, Watson M, Liddon N, Stokley S. Barriers to human papillomavirus vaccination among US adolescents: a systematic review of the literature. JAMA Pediatr. 2014;168(1):76–82. [PubMed: 24276343]
11. Buster KJ, You Z, Fouad M, Elmets C. Skin cancer risk perceptions: a comparison across ethnicity, age, education, gender, and income. J Am Acad Dermatol. 2012;66(5):771–779. [PubMed: 21875760]
12. Pruitt SL, Shim MJ, Mullen PD, Vernon SW, Amick BC 3rd. Association of area socioeconomic status and breast, cervical, and colorectal cancer screening: a systematic review. Cancer Epidemiol Biomarkers Prev. 2009;18(10):2579–2599. [PubMed: 19815634]
13. Monnat SM, Rhubart DC, Wallington SF. Differences in Human Papillomavirus Vaccination Among Adolescent Girls in Metropolitan Versus Non-metropolitan Areas: Considering the Moderating Roles of Maternal Socioeconomic Status and Health Care Access. Matern Child Health J. 2016;20(2):315–325. [PubMed: 26511129]
14. Finney Rutten LJ, Wilson PM, Jacobson DJ, et al. A Population-Based Study of Sociodemographic and Geographic Variation in HPV Vaccination. Cancer Epidemiol Biomarkers Prev. 2017;26(4): 533–540. [PubMed: 28196849]
15. Gelman A, Miller E, Schwarz EB, Akers AY, Jeong K, Borrero S. Racial disparities in human papillomavirus vaccination: does access matter? J Adolesc Health. 2013;53(6):756–762. [PubMed: 23992645]
16. United States Office of Information and Regulatory Affairs, Office of Management and Budget (OMB), Executive Office of the President. 2010 Standards for Delineating Metropolitan and Micropolitan Statistical Areas United States Federal Register, Volume 75, Number 123 Washington, DC: United States Office of Management and Budget 6 28, 2010 Available at: https://www.federalregister.gov/documents/2010/06/28/2010-15605/2010-standards-for-delineating-metropolitan-and-micropolitan-statistical-areas. Accessed October 1, 2017.
17. U.S. Census Bureau. Poverty Thresholds by Size of Family and Number of Related Children Under 18 Years, 2011–2012; 2013 U.S. Census Bureau Website. Available at: https://www.census.gov/topics/income-poverty/poverty/data/tables.html Accessed: October 22, 2018.
18. Rural Health Research Center. Rural-Urban Commuting Areas (RUCAs). Seattle, WA: University of Washington; 2007 Available at: http://depts.washington.edu/uwruca/ruca-rural.php. Accessed March 3, 2018.
19. Meilleur A, Subramanian SV, Plascak JJ, Fisher JL, Paskett ED, Lamont EB. Rural residence and cancer outcomes in the United States: issues and challenges. Cancer Epidemiol Biomarkers Prev. 2013;22(10):1657–1667. [PubMed: 24097195]
20. Hart LG, Larson EH, Lishner DM. Rural definitions for health policy and research. Am J Public Health. 2005;95(7):1149–1155. [PubMed: 15983270]
21. US Census Bureau. 2010 Census Urban and Rural Classification and Urban Area Criteria. Available at: https://www.census.gov/geo/reference/ua/urban-rural-2010.html. Accessed: October 22, 2018.
22. Rural Health Research Center. Rural-Urban Commuting Areas (RUCAs). Seattle, WA: University of Washington; 2007 Available at: http://depts.washington.edu/uwruca/ruca-uses.php. Accessed September 1, 2018.
23. Adler NE, Newman K. Socioeconomic disparities in health: pathways and policies. Health Aff (Millwood). 2002;21(2):60–76. [PubMed: 11900187]
24. Diez Roux AV. Investigating neighborhood and area effects on health. Am J Public Health. 2001;91(11):1783–1789. [PubMed: 11684601]
25. Shariff-Marco S, Yang J, John EM, et al. Impact of neighborhood and individual socioeconomic status on survival after breast cancer varies by race/ethnicity: the Neighborhood and Breast Cancer Study. Cancer Epidemiol Biomarkers Prev. 2014;23(5):793–811. [PubMed: 24618999]
26. Lantz PM, Mujahid M, Schwartz K, et al. The influence of race, ethnicity, and individual socioeconomic factors on breast cancer stage at diagnosis. Am J Public Health. 2006;96(12):2173–2178. [PubMed: 17077391]

27. Gomez SL, Glaser SL, McClure LA, et al. The California Neighborhoods Data System: a new resource for examining the impact of neighborhood characteristics on cancer incidence and outcomes in populations. Cancer Causes Control. 2011;22(4):631–647. [PubMed: 21318584]
28. Fan JX, Wen M, Wan N. Built Environment and Active Commuting: Rural-Urban Differences in the U.S. SSM Popul Health. 2017;3:435–441. [PubMed: 29124104]
29. CDC. Centers for Disease Control and Prevention. Teen Vaccination Coverage A User's Guide for the 2013 Public-Use Data File National Immunization Survey (NIS) - Teen. Atlanta, GA: CDC Available at: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISTEENPUF13_DUG.pdf Accessed January 15, 2017.
30. SAS Institute Inc., Cary, NC.
31. SAS Institute Inc. The GLIMMIX procedure: SAS Institute, Cary, NC; 2005.
32. Henry KA, Stroup AM, Warner EL, Kepka D. Geographic Factors and Human Papillomavirus (HPV) Vaccination Initiation among Adolescent Girls in the United States. Cancer Epidemiol Biomarkers Prev. 2016;25(2):309–317. [PubMed: 26768989]
33. Henry KA, Swiecki-Sikora AL, Stroup AM, Warner EL, Kepka D. Area-based socioeconomic factors and Human Papillomavirus (HPV) vaccination among teen boys in the United States. BMC Public Health.2017;18(1):19. [PubMed: 28709420]
34. Katz ML, Reiter PL, Heaner S, Ruffin MT, Post DM, Paskett ED. Acceptance of the HPV vaccine among women, parents, community leaders, and healthcare providers in Ohio Appalachia. Vaccine. 2009;27(30):3945–3952. [PubMed: 19389447]
35. Vanderpool RC, Dressler EV, Stradtman LR, Crosby RA. Fatalistic beliefs and completion of the HPV vaccination series among a sample of young Appalachian Kentucky women. J Rural Health. 2015;31(2):199–205. [PubMed: 25640763]
36. Shell R, Tudiver F. Barriers to cancer screening by rural Appalachian primary care providers. J Rural Health. 2004;20(4):368–373. [PubMed: 15551854]
37. Blumling AA, Thomas TL, Stephens DP. Researching and Respecting the Intricacies of Isolated Communities. Online J Rural Nurs Health Care. 2013;13(2):122–148.
38. Newkirk V AD. The Affordable Care Act and Insurance Coverage in Rural America. Kaiser Family Foundation 5 29, 2014 Available at: https://www.kff.org/uninsured/issue-brief/the-affordable-care Accessed: October 22, 2018.
39. Head KJ, Vanderpool RC, Mills LA. Health care providers' perspectives on low HPV vaccine uptake and adherence in Appalachian Kentucky. Public Health Nurs. 2013;30(4):351–360. [PubMed: 23808860]
40. Mohammed KA, Subramaniam DS, Geneus CJ, et al. Rural-urban differences in human papillomavirus knowledge and awareness among US adults. Prev Med. 2018;109:39–43. [PubMed: 29378268]
41. "State Information." States with Influenza Vaccine Mandates for Childcare. Available at: http://www.immunize.org/laws/flu_childcare.asp. Accessed October 22, 2018.
42. Walker TY, Elam-Evans LD, Singleton JA, et al. National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13–17 Years - United States, 2016. MMWR Morb Mortal Wkly Rep. 2017;66(33):874–882. [PubMed: 28837546]
43. Lowery NE, Belansky ES, Siegel CD, Goodspeed JR, Harman CP, Steiner JF. Rural childhood immunization. Rates and demographic characteristics. J Fam Pract. 1998;47(3):221–225. [PubMed: 9752375]
44. "State Information" Influenza Vaccine Mandates for Children in Daycare Facilities. Available at: http://www.immunize.org/laws/menin_sec.asp. Accessed October 22, 2018.
45. Lai D, Ding Q, Bodson J, Warner EL, Kepka D. Factors Associated with Increased HPV Vaccine Use in Rural-Frontier U.S. States. Public Health Nurs. 2016;33(4):283–294. [PubMed: 26331614]
46. Shipman SA, Lan J, Chang CH, Goodman DC. Geographic maldistribution of primary care for children. Pediatrics. 2011;127(1):19–27. [PubMed: 21172992]
47. Zimet GD, Shew ML, Kahn JA. Appropriate Use of Cervical Cancer Vaccine. Annual Review of Medicine. 2008;59(1):223–236.
48. Schuler CL, Reiter PL, Smith JS, Brewer NT. Human papillomavirus vaccine and behavioural disinhibition. Sex Transm Infect. 2011;87(4):349–353. [PubMed: 21357601]

49. Pew Research Center, May 2018, “What Unites and Divides Urban, Suburban and Rural Communities.” 5 2018 Available at: http://www.pewsocialtrends.org/2018/05/22/what-unites-and-divides-urban-suburban-and-rural-communities/. Accessed October 22, 2018

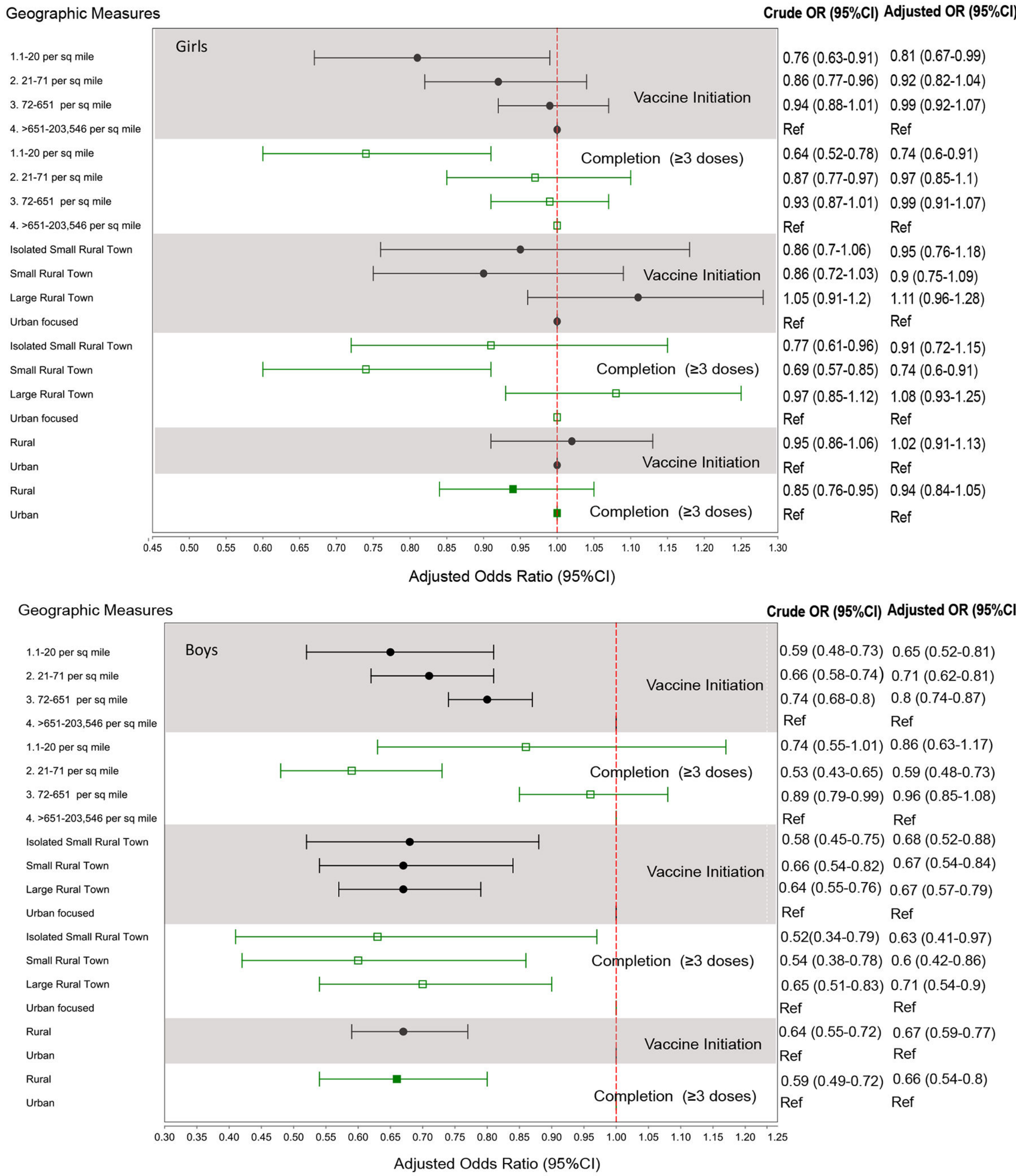

Figure 1.

Adjusted Odds of Initiation (Receipt of at Least 1 Dose) and Completion (Receipt of ≥3 Doses) Among Boys (top) and Girls (bottom) Aged 13 to 17 Years and Their Families: National Immunization Survey – Teen, 2012–2013.

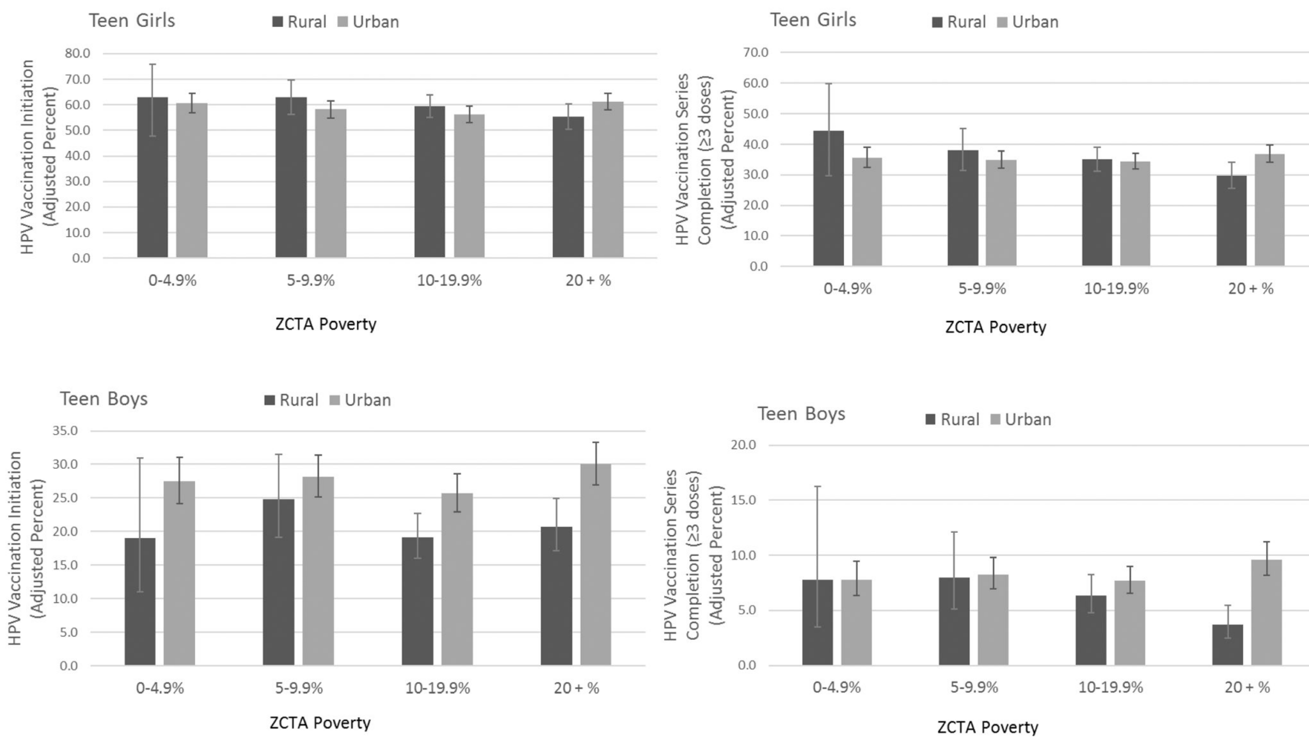

Figure 2.

Model Adjusted Percent of Girls (top) and Boys (bottom) That Initiated HPV Vaccination and Series Completion (receipt of ≥3 doses) by ZCTA Poverty and Urban and Rural Residence. The adjusted percentages are based on multivariable logistic regression models.

Table 1.

Geographic[a] Characteristics of HPV Vaccine Initiation (Receipt of at Least 1 Dose) and Completion (Receipt of ≥3 Doses): Teen Girls Aged 13 to 17 Based on Responses From the National Immunization Survey-Teen, 2012-2013

Characteristics	Survey Participants, n weighted %	Weighted % (95% CI), Vaccine Initiation (Yes)	*P* value	Weighted % (95% CI), Vaccine ≥3 Doses	*P* value
Total	17596	55.6 (54.3 – 56.9)		35.3 (33.5-37.2)	
Geographic Measures by ZIP Code					
ZIP Code Poverty (% below poverty) (POVERTY1Z)			.0002		.3540
1 - 0-4.99 %, least impoverished	2598 (12.8)	54.8 (51.7 – 58.0)		36.3 (33.3 – 39.3)	
2 - 5-9.9%	4621 (23.9)	54.4 (51.7 – 57.0)		36.1 (33.5 – 38.8)	
3 - 10-19.9%	6422 (37.2)	53.2 (51.0 – 55.4)		33.9 (31.8 – 35.9)	
4 - 20+%, poorest	3841 (26.1)	61.2 (58.3 – 64.0)		36.5 (33.6 – 39.5)	
Residence Type (RUCA)			.1499		.0018
Isolated Small Rural Town	868 (2.23)	51.0 (44.5 – 57.5)		30.0 (24.6 – 35.3)	
Small Rural Town	870 (3.02)	50.2 (44.4 – 56.1)		26.8 (22.1 – 31.6)	
Large Rural Town	1486 (5.67)	55.9 (51.3 – 60.5)		34.0 (29.5 – 38.5)	
Urban focused	14262 (89.1)	56.0 (54.6 – 57.5)		35.9 (34.5 – 37.4)	
Residence Type (RUCA)			.1331		.0049
Rural	3224 (10.9)	53.3 (50.1 – 56.5)		31.2 (28.3 – 34.1)	
Urban	14262 (89.1)	56.0 (54.6 – 57.5)		35.9 (34.5 – 37.4)	
Population density, (Quartiles)			.0033		.0002
1.1-20 per sq mile	1301 (3.20)	48.3 (42.7 – 54.0)		26.1 (21.9 – 30.3)	
2. 21-71 per sq mile	2236 (9.16)	51.6 (48.2 – 55.2)		32.3 (29.0 – 35.6)	
3. 72-651 per sq mile	4891 (27.3)	54.9 (52.4 – 57.4)		34.8 (32.3 – 37.2)	
4. >651-203,546 per sq mile	9058 (60.3)	57.1 (55.3 – 59.0)		36.6 (34.8 – 38.5)	

[a]Geographic level: ZCTA ZIP Code Tabulation Areas

Table 2.

Geographic[a] Characteristics of HPV Vaccine Initiation (Receipt of at Least 1 Dose) and Completion (Receipt of ≥3 Doses): Teen Boys Aged 13 to 17 Based on Responses From the National Immunization Survey-Teen, 2012-2013

Characteristics	Survey Participants, n weighted %	Weighted % (95% CI), Vaccine Initiation (Yes)	*P* value	Weighted % (95% CI), Vaccine ≥3 Doses	*P* value
Total	19,518	27.9(26.6 - 29.2)		10.4 (9.48 – 11.3)	
Geographic Measures by ZIP Code					
ZIP Code Poverty (% below poverty) (POVERTY1Z)			< .0001		.0217
1 - 0-4.99%, least impoverished	2981 (13.5)	24.4 (21.6 – 27.1)		9.01 (7.01 – 11.0)	
2 - 5-9.9%	5192 (25.2)	25.5 (23.3 – 27.8)		9.52 (8.07 – 11.0)	
3 - 10-19.9%	7170 (36.4)	25.3 (23.2 – 27.4)		9.14 (7.82 – 10.5)	
4 - 20+%, poorest	4070 (24.9)	34.8 (32.0 – 37.6)		12.9 (10.8 – 15.1)	
Residence Type (RUCA)			< .0001		< .0001
Isolated Small Rural Town	964 (2.32)	17.3 (13.5–21.2)		5.31 (3.33 – 7.30)	
Small Rural Town	938 (3.07)	18.7 (13.9 – 23.4)		5.50 (3.32 – 7.67)	
Large Rural Town	1715 (5.66)	18.6 (15.6 – 21.5)		6.45 (4.69 – 8.21)	
Urban focused	15799 (89.0)	28.7 (27.4 – 30.1)		10.7 (9.74 – 11.6)	
Residence Type (RUCA)			< .0001		< .0001
1. Rural	3617 (11.0)	18.3 (16.2 – 20.5)		5.95 (4.78 – 7.11)	
2. Urban	15799 (89.0)	28.7 (27.4 – 30.1)		10.7 (9.74 – 11.6)	
Population density, (Quartiles)			< .0001		< .0001
1. 1-20 per sq mile	1472 (3.25)	19.3 (15.5 – 23.1)		8.10 (5.08 – 11.1)	
2. 21-71 per sq mile	2516 (10.3)	20.4 (17.1 – 23.7)		5.63 (3.99 – 7.28)	
3. 72-651 per sq mile	5504 (27.0)	23.4 (21.2 – 25.6)		9.44 (7.79 – 11.1)	
4. >651-203,546 per sq mile	9924 (59.5)	31.2 (29.4 – 32.9)		11.4 (10.2 – 12.6)	

[a]Geographic level: ZCTA ZIP Code Tabulation Areas