Spatial Analysis of HPV Vaccination Rates in Chicago

UTILIZING GEOGRAPHIC INFORMATION SYSTEMS SOFTWARE TO ANALYZE RATES OF ADOLESCENT HPV IMMUNIZATION ACROSS CLINICS OF CHICAGO

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ABSTRACT

Background: Persistent infection of Human Papilloma Virus (HPV) is the leading cause of cervical cancer in women and can lead to reproductive health problems in both men and women (1). Although this is widely recognized by health professionals and understood to be preventable by a basic vaccine series, certain cities of Chicago are still struggling to vaccinate their adolescent patients. This is a widely recognized issue, and one that (unlike many other public health problems) has a solution.

Methods: This analysis utilized geographic information systems (GIS) and de-identified clinic-level data from the Chicago Department of Public Health in order to visualize the rates of HPV vaccination across Vaccines for Children providers in the city and to determine areas of the city that education or communication efforts to improve the HPV vaccination rate need to be directed towards. The visual, geospatial data was also subject to statistical analysis in order to determine statistically significant hot and cold spot trends of vaccination across Chicago clinics.

Results: The trends observed in this analysis are consistent with other public health disparities in the city—zip codes on the south side of Chicago maintained low rates of vaccination across their clinics while the northern and western zip codes seemed to perform far more superior. Specifically, zip codes 60628, 60620, and 60643 were “cold spots” for this data and represent most of the well-known southern Chicago neighborhoods most affected by the clear health disparity. On the other hand, zip codes 60634, 60707 and 60639 represented the “hot spots” for

high vaccination rates and populated the city's medical district and academic hospital communities.

Discussion: It is important to recognize that racial and health disparities go hand in hand, and this analysis brings to light a similar point. By understanding the patients that are served in clinics with significantly low rates of HPV vaccination, the city can better understand the types of interventions that will facilitate the city's improvement in their rates of HPV vaccination. This analysis is important and relevant for the Chicago Department of Public Health and can be used to further launch client-centered or communication-based interventions in clinics themselves in order to improve vaccination recommendations, increase series completion rates and bring the city up to meet their goal of 80% adolescents vaccinated against HPV.

BACKGROUND

Human Papilloma Virus (HPV) is a preventable sexually transmitted disease that affects both men and women, and is estimated to newly infect nearly 6 million people each year (2). The disease is a series of nearly 150 different viruses and is so common in the United States that nearly all men and women will experience the virus in one form or another. The virus can be asymptomatic and usually resolves on its own but in the cases that it does not, persistent infection of HPV can result in various cancers in the vagina, vulva, penis, anus, rectum and/or oropharynx (3). Clinical trials have shown that the HPV vaccine confers nearly 100% protection against cervical precancers and genital warts and it is recommended that all adolescent males and females should start the vaccination administration around ages 11 or 12 (4). The vaccine has shown to be most

effective when given well before exposure to the virus. The vaccine is a two- or three-part series, depending on the age of the first dose. Despite the efficacy of the vaccination, however, there is a concerning pushback from individuals that reject and refuse immunizations as a whole. The choice to not vaccinate oneself or one's children usually comes from a place of misconception, biased research or lack of proper information. It remains a public health struggle today to increase coverage of various immunizations across the country, as an individual without a vaccination to a certain disease or virus could pose great danger to not only themselves but vulnerable individuals around them.

Public efforts over recent years have involved increasing the coverage of HPV vaccination among both adolescent males and females across the country. Not only is it a national goal to increase awareness and spark improvement in administration rates of this vaccine, it is also a shared goal among many states and local departments of public health (5). The latest data for vaccination coverage in Chicago states that less than half of both males and females have completed their HPV vaccine series. More specifically, only 41.9% of girls and 28.1% of boys of 13-17 years of age received the complete 3-dose series in 2015 (6). The Chicago Department of Public Health, recognizing that this and other relevant public health problems need to be approached collaboratively in order to be solved, is joined by a variety of supporters and stakeholders to develop a plan called Healthy Chicago 2.0. In this strategic plan, the city has made 30 goals with over 200 objectives towards achieving those goals revolving around health equity and improving the health of the citizens of Chicago. A relevant goal from this plan is: Reduce the Incidence and Inequities in Invasive and Late Stage Cancers and Cancer Mortality with the objective to increase the percentage of adolescent females with up to date vaccines to 80% (5).

This requires an estimated 52% increase from the city's baseline. The city of Chicago supports the HPV vaccine as cancer prevention and encourages all adolescents to receive the complete dosage before turning 18 years old. Because the rate is so low across the city, the department of public health has engaged in various programs such as the Vaccines for Children Program, which "offers vaccines at no cost for eligible children through doctors enrolled in this program" (7). This federally funded program removes the financial barriers that are ever present in today's society for adequate healthcare. Most children eligible for this program are seen in federally qualified health centers or any other participating provider or clinic. Participating providers report patient data back to their local coordinators. Utilizing the information that these clinics send to the health department can be useful in determining the areas of the city specifically that need more attention in terms of HPV vaccination rate.

The public health problem being addressed in this analysis is both a simple and quite complex one. Unlike most health issues, cervical cancer and other diseases caused by HPV can be effectively and almost completely prevented by completion of the vaccination series. At the same time, however, the reason for the clear lack of administration by healthcare providers or compliance of patients and/or parents is deeply rooted in race, poverty and socioeconomic status. More simply put, the health and vaccination status of Chicago residents can be predicted with some accuracy according to zip code. A study examining the social determinants of delaying the HPV vaccination from data provided by the National Immunization Survey showed that there are clear racial and ethnic variations in parents' decisions to begin or delay an HPV vaccination for their child (8). Although this study found little evidence for the direct association between socioeconomic status and vaccination delay, it is still important to understand that

socioeconomic status and race are inextricably linked and should still be a factor for consideration. Mitigation of the recognized disparity can be done and done well using various interventions or educational tools in clinics, but elimination of this inequity can only be accomplished by recognizing and addressing the core of the social determinants of health (9, 10).

With that being said, public health professionals have still made valiant efforts to recognize, address and combat the disparity of HPV vaccination rates at the clinic-level. The Centers for Disease Control funds and administers a program called AFIX—which stands for Assessment, Feedback, Incentives and eXchange. It is designed around the problem of low immunization rates and is used to empower, educate and motivate providers to change their immunization practices and sustain better behaviors to facilitate better immunization coverage. The program begins with an evaluation of coverage rates at the provider level and helps to meet the facility where they are at in order to improve their healthcare provider behavior and vaccination practices. The process of this program involves assessing provider vaccination rates via medical records, offering feedback to providers about their coverage performance and to discuss next steps to improve, incentivizing providers to motivate and instill long-lasting change and exchanging this information with fellow providers, members of the community, educational forums, etcetera. The Vaccines for Children Program and AFIX have linked together in recent years in order to streamline the process of increasing accessibility of vaccines for patients as well as making the process of administration easier for providers as well. AFIX has adopted several evidence-based strategies that are endorsed to participating providers that have been shown to improve immunization coverage at the clinic level. Among the many strategies include an easier recordkeeping system, the need for reminders, recommendations and reinforcement of the need

to return, reduction of missed opportunities to vaccinate and reduction of barriers to immunization within the practice (11). Addressing these strategies with providers directly is key to reducing the disparity of vaccination coverage at the provider level.

Researchers in southern California recognized the important role and influence providers have on ensuring the HPV vaccination of their adolescent patients. While advocating for the idea that patients with a medical home will receive more structured and likely more compliant healthcare, the authors also recognized that the actions performed by all staff in a clinic during one single visit can impact the decision of a parent or patient to receive or finish the vaccine series. According to this study, report hard times initiating and completing HPV vaccine administrations due to time, budget, staffing and/or knowledge constraints and well performing clinics utilized a collaborative approach to patient education and framed the importance of the vaccine in an understandable and appropriate, yet still urgent way (12). Well performing clinics utilized a collaborative approach to educate and support patients and their parents regarding the HPV vaccination. From a patient's first point of contact to their last in clinic, if they are being educated and provided with resources and encouragement these patients can be much more likely to consider, initiate or complete the series. This involves every staff member at a clinic from the medical assistant to the physician. Viewing vaccination as a "team effort" can make the idea of advocating for a somewhat controversial vaccine less daunting and more achievable in any clinic that sees young adult or adolescent patients.

This idea is also supported by a geospatial analysis of HPV associated cancers and chlamydia in various Los Angeles county neighborhoods and their proximities to vaccine service providing clinics. The authors found that high risk neighborhoods, or neighborhoods with low

rates of vaccination, had geographically accessible clinics so access to infrastructure may not be the problem.

> "Although immunization services are geographically available and costs are reduced through the VFC program, the low uptake of HPV vaccines among adolescent girls seen in our study and in nationally reported rates suggest the need to explore other health care organizational factors that may serve as barriers to vaccination" (13).

The authors of this study also bring to light the importance of minimizing missed vaccination opportunities in clinic settings and the influence of the political climate on the adherence to vaccination recommendations. Studies similar to this one highlight the necessity of also focusing on the opposite end of the vaccine spectrum—the importance of directing our attention from the receiver to the provider.

Missed clinical opportunities to advocate for the HPV vaccination are not uncommon and are a shared concern among many healthcare providers (14). Although national guidelines on all vaccinations, including HPV, exist, physicians are still facing barriers to recommendation of the HPV vaccine to their patients. In a similar sentiment as previously described, providers noted policy-level factors such as financing or budgeting issues influencing the likelihood of always recommending the vaccination. According to the health belief model, there is a direct impact on whether or not providers choose to recommend the vaccine to their patients if there are perceived barriers recognized by the physician (15). Communication has been previously seen as burdensome by physicians in similar studies (16). Some providers believe that there is an

increasing challenge because the vaccination isn't mandated, there may be significant parent pushback or because of the associated stigma that accompanies the vaccine.

From a patient or parents' perspective, however, it has been recognized that recommendation by a physician can drastically influence the decision to initiate or complete the HPV vaccination series. A mixed methods study investigating the mediating relationship provider recommendations have on a parents' decision to initiate or complete the series showed that, in addition to having sufficient knowledge of the disease and the vaccine, being recommended the vaccine by the healthcare provider can, in some cases, more than double the odds of the adolescent actually receiving the vaccination (17). The problem becomes illuminated in research such as this one. There is a consensus that healthcare providers have a great deal of influence on the patients or parents that are being seen in the healthcare setting. Recommending or advocating for the vaccination can help the disparity of vaccination coverage that is evident across areas of Chicago, however it is clear that there are still issues to overcome in terms of clinic- or provider-level barriers to achieve the resolution both the country and the city are striving for.

This project explored the rate of full completion of HPV immunization across the city of Chicago in order to identify particular areas of Chicago that need more attention or resources towards providing the immunization series. As partners of this project at the Chicago Department of Public Health shared the hypothesis that there exists a clear north/south disparity even among clinics across the city of Chicago for the completion of HPV vaccination rates, the aim of this project was to visually represent the existing data and to hopefully bring that representation to fruition. The implications of this project are two-fold. Visualization of geographic data

representing HPV vaccination rates has not been done for the city yet and can be useful as a reference tool for all visitors to the department's website as well as stakeholders involved in the efforts to increase awareness around HPV vaccinations for young men and women. Furthermore, the team that is already working on expanding the vaccination coverage of HPV can utilize this data to determine which clinics or areas of Chicago need better resources on education or administration of the HPV vaccine, and which clinics are doing well with regards to ensuring their patients are protected from HPV related precancers and cancers. By using geographic information systems technology, the rates of HPV vaccine completion can be interpolated for parts of the city that are missing data and then statistically analyzed for areas of significant clusters of high or low HPV vaccination rates. The hypotheses shared by the team entering into this project were the idea that the completion of the HPV vaccine series suffers the same health disparity as most other public health issues do in the city. That is, the southern zip codes or areas of Chicago will produce data with clinics that have a smaller percentage of patients completing the vaccine series.

METHODS

Description of Data

This project was done in collaboration with Dr. Marielle Fricchione at the Chicago Department of Public Health. After discussion with her and other members of the team, the data used for this project was compiled and sent to me from the CDPH to analyze. Data was collected through the Chicago Department of Public Health's database of participating Vaccines for Children/AFIX clinics across the city. The self-reported, de-identified data from clinics consisted of 2 years'

worth of vaccination services for patients in the Vaccines for Children program. The 2016 data included information from 137 different clinics across Chicago and the 2017 data included information from 93 clinics across Chicago. These data were received from the Chicago Department of Public Health and included the following relevant data: total number of patients assessed that were participating in the Vaccines for Children program, percentage of adolescents with all three completed HPV vaccination administrations, healthcare provider address, a unique provider code, provider zip code. This data is not publicly available and was sent to me de-identified and compiled with only the data that would be relevant for this project.

Methodology

Relevant data was compiled and imported into Microsoft Excel and zip code data were formatted into text files in order to be readable by the geographic information systems software. 2016 and 2017 data were compiled into one table. Only six clinics had reported data for both years, and for this situation the number of patients assessed and number of patients with full vaccine series were averaged over the course of the two years. Data provided was extrapolated (rate multiplied by total patients assessed) to determine number of patients by clinic that were vaccinated with the complete series. This led to each clinic having an associated *total number* of patients completing the vaccine and not just a rate. This data was then imported into ArcCatalog (from ArcGIS 10.5.1 software) in a newly created file geodatabase. Chicago streets and zip code boundary shape files were downloaded from the CDPH website and imported into the same geodatabase. All data was imported into ArcMap 10.5.1 as one geodatabase and data was projected into the NAD 1983 US Feet State Plane (Illinois East FIPS 1201) projection.

Imported clinic data had an associated zip code to it, according to the address provided by the CDPH. In most cases, multiple clinics were represented in a single zip code, so this data was then able to be summarized by adding up the total number of adolescents assessed (SUM function) and the total number of patients with completed HPV vaccination series (SUM function). This produced a table with the total number of adolescents assessed and total number of patients with a completed HPV vaccination series per each zip code of Chicago. A "double" field was added to this table, named HPV_Rate, and was assigned to be calculated as: total number of full vaccine series patients divided by total number of patients assessed per zip code. Chicago zip code shape files were then joined to the HPV_Rate data using the zip code field to join the two. This action essentially associated the zip code shape file (the zip code border map layer) to actual HPV vaccination rate data. An address locator was created using dual ranges and the Chicago streets shapefile, utilizing addresses and latitude/longitude data according to each clinic and placing the clinic locations on the existing map. Provider data addresses were geocoded and matched 98% of the clinics. In the instances where addressed were not able to be matched, addresses were repaired or corrected and re-matched. Three clinics were excluded from this data because they existed outside the Chicago zip code boundaries.

Choropleth maps were created to represent the average rate of completed HPV vaccination series by color. The choropleth map was classified using 5 classes and natural breaks (ArcMap 10.5.1 natural breaks). This created a visual representation of the zip codes with higher rates of completed HPV vaccination as zip codes with a darker shade of blue and zip codes with lower rates of completed HPV vaccination as zip codes with a lighter shade of blue. A Kriging interpolation was conducted in order to estimate the zip codes of Chicago that were not

represented with provided or existing data. This is an interpolation method that generate estimations for geospatial data based on its surroundings, producing a prediction surface. This kind of interpolation is an advanced analytic procedure that assesses the geospatial behavior and patterns of the existing data and best produces an estimate for areas of the map surface that do not have data associated with it. A statistical analysis is also included in the interpolation that makes the assumption that there is a spatial correlation to the data that can explain the variation in the surface trends, and this interpolation was done because Chicago has very explicit spatial trends when it comes to public health indicators. This interpolation was done using a z-field of HPV_Rate, output cell size of 50 and number of points to use in the analysis of 3. The Kriging output produced a visually similar choropleth map using rates per unit area (instead of rates per zip code) and used the same choropleth theme colors as the crude data map.

The Kriging data was used to create a zonal statistics-to-table output, which created tabular data per unit area created with the Kriging calculation. This tabulated data was then confined to zip code data of Chicago and was able to produce average rates of completed HPV vaccination series per zip code of Chicago by averaging the value for each pixel of data that existed within each zip code boundary. This data was created to compare to the crude data to determine if missing data had an impact on the analysis. Getis-Ord Gi* hotspot analysis was performed on both the crude map and the Kriging interpolated and averaged map. This analysis is to determine where statistically significant hotspots are in comparison with neighboring values. Hot spots will be detected if the feature is surrounded by high values, and vis versa for cold spots. It will also be considered a hotspot (or coldspot) if the local sum of the significant areas differs significantly from the expected sum determined by summing the value of all the features on the

map surface. Z scores and p-values were produced as an output of this analysis, but more important to this project were the confidence intervals of the hot and cold spots. Confidence intervals describe to what degree is the hot (or cold) spot truly existing on the map is due to random chance or not. The greater the percentage, the less of a chance there is for this to be the case. This analysis produces three different confidence intervals on the map following the analysis. Overlay of poverty levels per zip code were not used as they typically are in Chicago data analysis because this data represents *clinic* coverage and not necessarily patient residence. Although most clinics of the city serve patients that are located in similar areas, to avoid ecological fallacy about the residents of the city this assumption could not have been made in this analysis.

RESULTS

The Kriging output produced data per pixel or square area across the entire city of Chicago. This interpolated data for zip codes of Chicago that were missing data. Figure 1 (Appendix A) is the result of the interpolation. Parts of the city were excluded from this interpolation as seen in the southeast and northwest corners of the city due to constraints with the geographic information systems software and its ability to interpolate past a certain distance of the provided data. Completed HPV vaccination series rates range in this map from 6% to 73.3% and are coded and represented by intensity of blue.

Figure 2 (Appendix A) represents a comparison of crude data versus interpolated data for zip code HPV vaccination rates. The classifications were kept in the same ranges to confer easier visual interpretation. The missing zip codes in the crude data came from mostly the “Near North

Side". Completed HPV vaccination series rates range from 13.2% to 76% and are represented by the same color code as the Kriging interpolated map.

Figure 3 (Appendix A) represents the Getis-Ord-Gi* output for both crude and interpolated data. The cold spots, with 99% confidence, from the crude data include: 60628, 60620, and 60643. These zip codes contained the neighborhoods Roseland, Pullman, West Pullman, Riverdale, Washington Heights, Auburn Gresham, Greater Grand Crossing, Chatham, Beverly, Ashburn and Morgan Park. The cold spot, with 95% confidence, from the crude data include: 60827. This zip code comprises of the Riverdale neighborhood. The cold spot, with 90% confidence, from the crude data include: 60617. The 60617 zip code contains the South Deering, East Side, Hegewisch, Calumet Heights, Avalon Par and South Chicago neighborhoods.

The cold spots, with 99% confidence, from the interpolated data include: 60633, 60628, 60827, 60643. These zip codes included the Hegewisch, Riverdale, Roseland, Pullman, Washington Heights, West Pullman, Beverly and Morgan Park neighborhoods. Cold spots, with 95% confidence, from the interpolated data include: 60617, 60620, 60621. These zip codes contained the neighborhoods of South Deering, East Side, Calumet Heights, Avalon Park, South Chicago, Auburn Gresham, Greater Grand Crossing, Chatham, Roseland, Englewood and Washington Park. Cold spots, with 90% confidence, from the interpolated data include: 60637, 60615, 60636, 60609. The neighborhoods contained in these zip codes included Woodlawn, Hyde Park, Grand Greater Crossing, South Shore, Washington Park, Grand Boulevard, Kenwood, West Englewood, Englewood, Chicago Lawn, Gage Park, McKinley Park, Bridgeport, New City and Fuller Park.

Hot spots, with 99% confidence, from the crude data include: 60634, 60707 and 60639. These neighborhoods are Dunning, Portage Park, Belmont Cragin, Monclare and Hermosa. Hot spots, with 95% confidence, from the crude data include: 60641, 60647, 60614 and 60622. These zip codes comprised of Portage Park, Irving Park, Avondale, Hermosa, Belmont Cragin, Logan Square, Humboldt Park, West Town and Lincoln Park neighborhoods. Hot spots, with 90% confidence, from the crude data include: 60618, 60642 and 60610. The corresponding neighborhoods were Irving Park, North Center, Avondale and Near North Side.

Hot spots, with 99% confidence, from the interpolated data include: 60605, 60604, 60603, 60602, 60601, 60611, 60661, 60606, 60654, 60610, 60614, 60642, 60612 and 60707. These neighborhoods included Near North Side, The Loop, Near West Side, Lincoln Park, Logan Square, Near West Side, Garfield Park, Humboldt Park, West Town, North Lawndale, Northclare, Belmont Cragin and Austin. Hot spots, with 95% confidence, from the interpolated data include: 60622, 60647, 60639 and 60641. The corresponding neighborhoods included West Tow, Logan Square, Near North Side, Hermosa, Humboldt Park, Belmont Cragin, Portage Park, Irving Park and Avondale. Hot spots, with 90% confidence, from the interpolated data include: 60651, 60634 and 60707. These were neighborhoods such as Humboldt Park, Austin, Dunning, Portage Park, Montclare, Belmont Cragin and Austin.

DISCUSSION

To begin, the overlap of neighborhoods with certain zip codes and the necessity of reporting both exposes a data issue that is relevant in the city and all organizations that interpret, analyze or collect city data. Although zip code data is used by many agencies to report and visualize

data such as this, zip codes sometimes do not tell the complete story and it might be easier to target interventions, programs, time or resources to clinics that exist within certain neighborhoods rather than clinics that exist within certain zip codes. Beside that point, the data and the subsequent analysis explicitly details the health disparity of the HPV vaccination across clinics of Chicago.

Addition of Kriging interpolation affected both hot and cold spot analysis of HPV vaccination rates. Interpolating the rates of completed HPV vaccination series to small map pixels or small areas of Chicago instead of larger zip code boundaries according to clinic data allow predictions to be made about zip codes according to all clinics and their success with administration of the vaccine series based on the existing patterns. The interpolation allowed better visualization of the areas of Chicago that, proven by data, need better HPV vaccination coverage as well as areas of Chicago that are not represented by the data that could possibly need better resources or help as well. Zip codes that are significant cold spots in Chicago on both crude and interpolated analysis include 60643 and 60628. These zip codes represent the neighborhoods Morgan Park, Washington Heights and Beverly (60643) and Pullman, West Pullman, Riverdale and Roseland (60628). Zip codes that are significant hot spots in Chicago on both crude and interpolated analysis include 60607 which represents part of the Greektown neighborhood, University Village and falls just East of the Illinois Medical District. Although these zip codes fall in separate areas of Chicago, they both share in common the close vicinity to many hospitals, negating the hypothesis that clinics closer to or associated with hospitals have better vaccination coverage. Further analysis into this issue may bring to light the hypothesis that most of the hospitals in the zip code 60607 are academic hospitals, focused on

teaching and research whereas hospitals in zip codes 60643 and 60628 are community hospitals. Although both zip codes share hospital-based clinics and sites that administer vaccinations, there may be a difference in the quality or standards of patient care. Academic hospitals, typically, may be more adherent to vaccination recommendation protocols because of additional training staff, residents or a variety of other factors that may contribute to more comprehensive vaccination administration and these hypotheses should be investigated further. Clinics in cold spot areas may need updated patient protocols or resources to support physicians and their clinical decision to promote the HPV vaccination.

There are drawbacks in an analysis such as this one. Because the data regarding patient demographics that the Chicago Department of Public Health received from participating clinics is all self-reported, there is a chance that the accuracy of the data is not correct or completely robust. Many of these clinics are already understaffed or have limited time or resources and reporting all of their patient encounters or additional administration information may prove to be difficult. Even if clinics do report, data might be under or over-estimated. This could potentially lead to an inaccurate representation of the patient demographic served at clinics, and although patient demographics were not explored in this project, it is a piece of data the city is interested in looking at so it is important to recognize the possibility of this gap in data. Additionally, there are clinics that exist in the city that do not participate in the Vaccines for Children program yet are still providing vaccines to their adolescent patients. This data is not similarly received by the department of public health and cannot be as easily measured or tracked. This makes the results of this analysis possibly inaccurate or missing important trends that might be important to notice and recognize for further public health interventions.

Furthermore, the only information given about the clinics represented in this analysis were addresses. If these clinics specialized in a certain practice of medicine, that was not provided and thus could not be analyzed further. It may be of interest to next examine trends according to specialty of practice and if the noticed trends in this analysis change in any way. Finally, because the data in this analysis is considered very recent, other data that could have possibly been used to overlay and observe associations or similar trends was not able to be used since most of it had not yet been compiled or analyzed by the department of public health. For example, upon discussion of future directions for this project, the department of public health expressed interest in examining data according to economic hardship index or Vaccines for Children patients versus non-Vaccines for Children patients. Some of that data, because of how recent this analysis is and required the matching data to be, had not been compiled or collected completely making the comparison of important indicators difficult to do, at least at this time point.

Future directions for this project have the potential to be widespread. The data used in this analysis was not stratified by gender—male and female rates of HPV vaccination completion were combined and represented as one number. It may be of interest to comb apart the data used for this project even more, to separate it and visualize if inequities still exist, reduce or are more magnetized when analyzing it according to gender. Additionally, it may be a future direction for the investigation of the client-level interactions that occur among the clinics that exist in both hot and cold spot zip codes. This research could observe the difference in the dynamics between patient and provider in terms of vaccine conversation or recommendation. Since many of these clinics are participating in the AFIX program, they are

already being reinforced with the strategies and ideas expressed in this analysisThis research could facilitate the initiation of a program or intervention that could spearhead better communication skills among poorer performing clinics for providers and their clients that may reduce the barriers for physicians to recommending the vaccine series to their patients or parents.

A goal of the Chicago Department of Public Health from the beginning of this project has been to bridge the gap between vaccinations and chronic disease. The data that have been analyzed in this project can be used in combination with publicly available cervical cancer data to make it visible to the public that hardship is linked to health outcomes and to bring to the forefront the need to discuss social determinants of health when considering public health or clinical health concerns. The bridging of these two issues can help facilitate more funding for intervention research or implementation, more resources or education for providers or healthcare clinics, or even help support the advocacy for the mandate of HPV vaccinations for school-aged children just like TDAP or meningitis vaccines.

This project elucidates the need for a more client-centered conversation regarding vaccinations and the associated risk that comes with choosing to not initiate the vaccination series and this is not new information. The AFIX program has recognized a need for this since its inception. Healthcare providers at all scales serve incredibly significant and influential roles when providing care for their patients and the HPV vaccination should be seen as something as routine to discuss as their patients' wellbeing. Normalizing the conversation of recommending the vaccine series to patients could be considered as one of the city's new objectives towards achieving the goal of 80% of adolescents having received the HPV vaccine. Being able to

visualize this data in a way that clearly describes the disparity in Chicago areas allows individuals from physicians or healthcare providers to lay individuals to parents understand the need to address the barriers that are seen in these areas and to support the infrastructure that is doing the difficult work of trying to overcome them.

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Appendix A

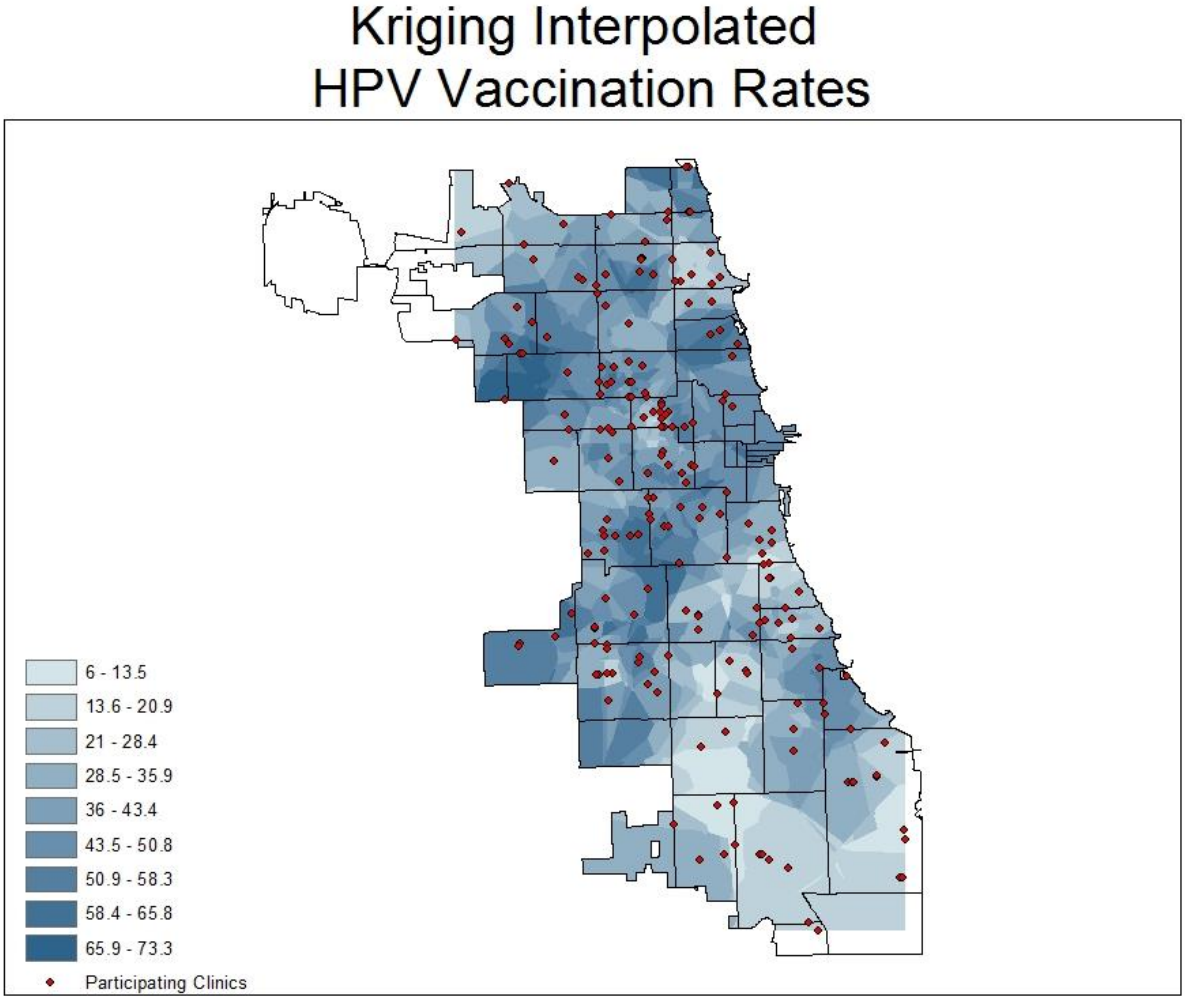

Figure 1. Kriging interpolated vaccination rates for completed HPV vaccine.

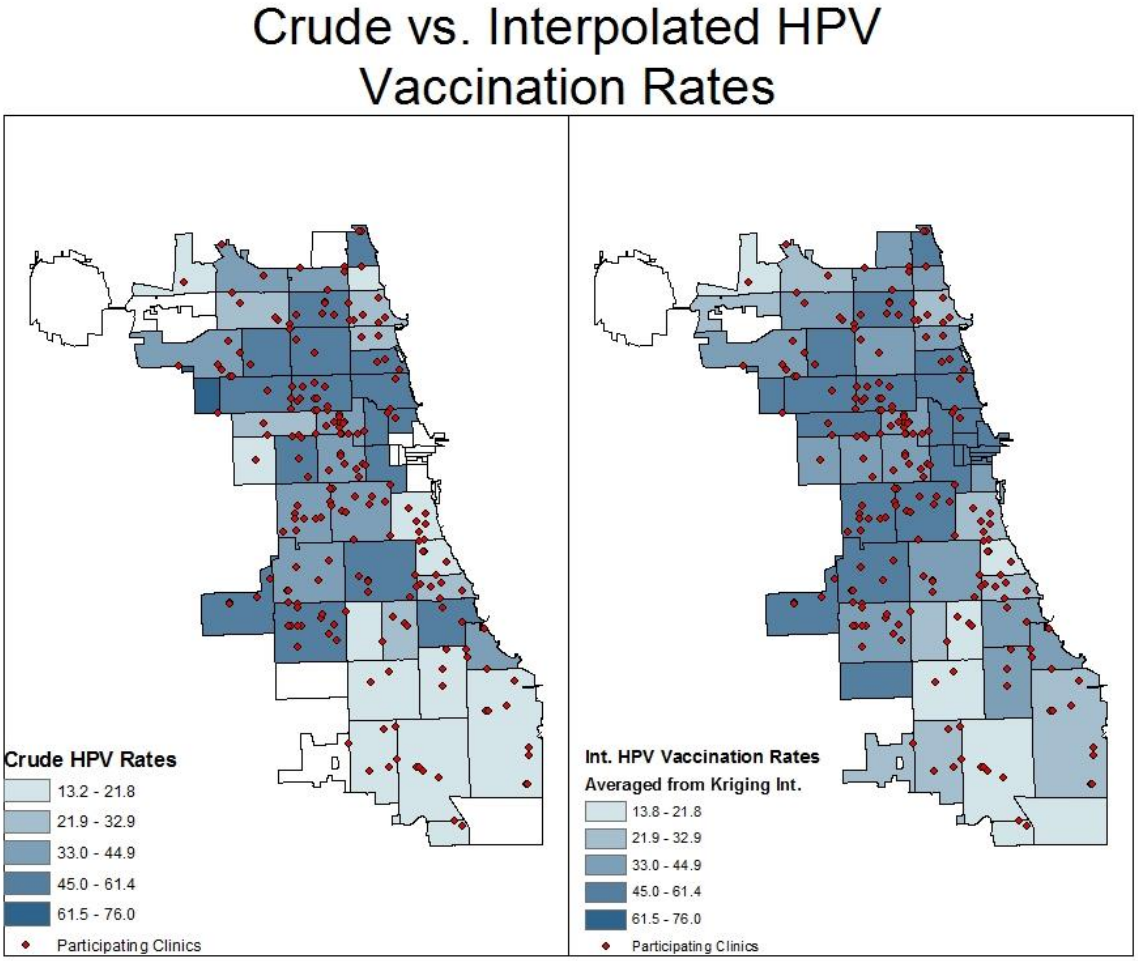

Figure 2. Crude vs. Interpolated completed HPV vaccination series across clinics of Chicago.

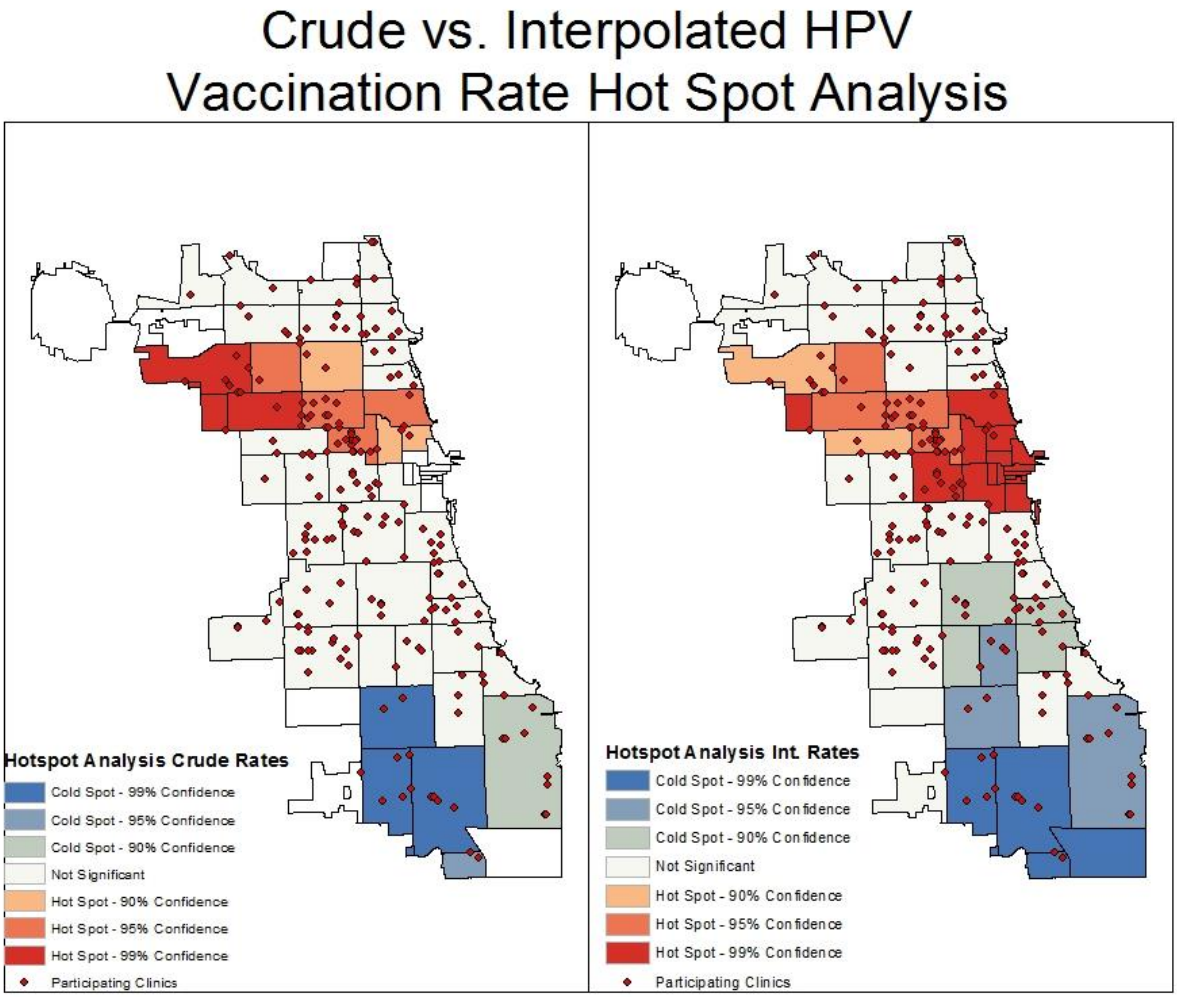

Figure 3. Getis-Ord-Gi* analysis of both crude and interpolated HPV vaccination rates across Chicago.