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Examining the Effect of Socioeconomic Factors on Kindergarten Vaccination Rates in Kentucky Counties

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Abstract

The purpose of this project is to examine the relationship between county-level socioeconomic factors and immunization compliance rates among kindergarten age children. All 120 counties in Kentucky were included in this evaluation.

County-level percent of uninsured children, number of children in poverty, children receiving free lunch (percentage), unemployment rate (percentage), and high school graduation rate were assessed. Socioeconomic data for each county were compared to county-level kindergarten vaccination rates. All vaccination data were obtained from the 2015-2016 Kentucky Annual School Immunization Survey Report. All socioeconomic county data were obtained from the 2016 County Health Rankings data, published by the Robert Wood Johnson Foundation.

County-level socioeconomic variables did not significantly differ between counties that met and did not meet all Healthy People 2020 vaccination goals. Higher rates of uninsured children were significantly related to higher compliance rates of total vaccination, MMR, Polio, and varicella. Higher rates of education (high school graduation rate and percent of adults with some college) were significantly related to higher DTaP and Polio vaccination rates.

This analysis provides guidance for target populations where best practices for improving vaccine compliance can be implemented.

Keywords: Kentucky, vaccination, child, kindergarten, county, socioeconomic impact

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I. Introduction

Vaccination requirements exist in the United States for all children enrolled in and attending public school systems. The Centers for Disease Control and Prevention (CDC) recommends that kindergarten aged (4-6 years old) children receive a minimum of five doses of diphtheria, tetanus, and acellular pertussis vaccine (DTaP), two doses of measles, mumps, and rubella vaccine (MMR), three doses of Hepatitis B vaccine (HepB), four doses of Polio vaccine, and two doses of Varicella vaccine prior to starting kindergarten (CDC, 2018). Specific requirements and exemptions are determined at the state level and vary significantly. Nationally, vaccination rates are relatively high, with median vaccination coverage at 95.1% for the state-required number of doses of DTaP, 94.3% for 2 doses of MMR, 96.0% for three doses of HepB, 94.2% for four doses of Polio, and 93.8% for 2 doses of Varicella (CDC, 2018). The Healthy People (HP) 2020 Immunization and Infectious Disease Objective 10 outlines targets for kindergarten age child vaccination rates as: 95% of children to have four or more doses of DTaP, three or more doses of polio, three or more doses of Hepatitis B, two doses of MMR, and two doses of Varicella (Healthy people 2020). While not drastically different than national vaccination rates, Kentucky compliance rates are lower across the board for all five vaccinations.

Vaccine requirements for children are recommended by the CDC based on age range, underlying factors, and physician discretion. The CDC regularly publishes an updated recommended pediatric vaccination schedule, shown in figure 1 (CDC, 2019).

Figure 1

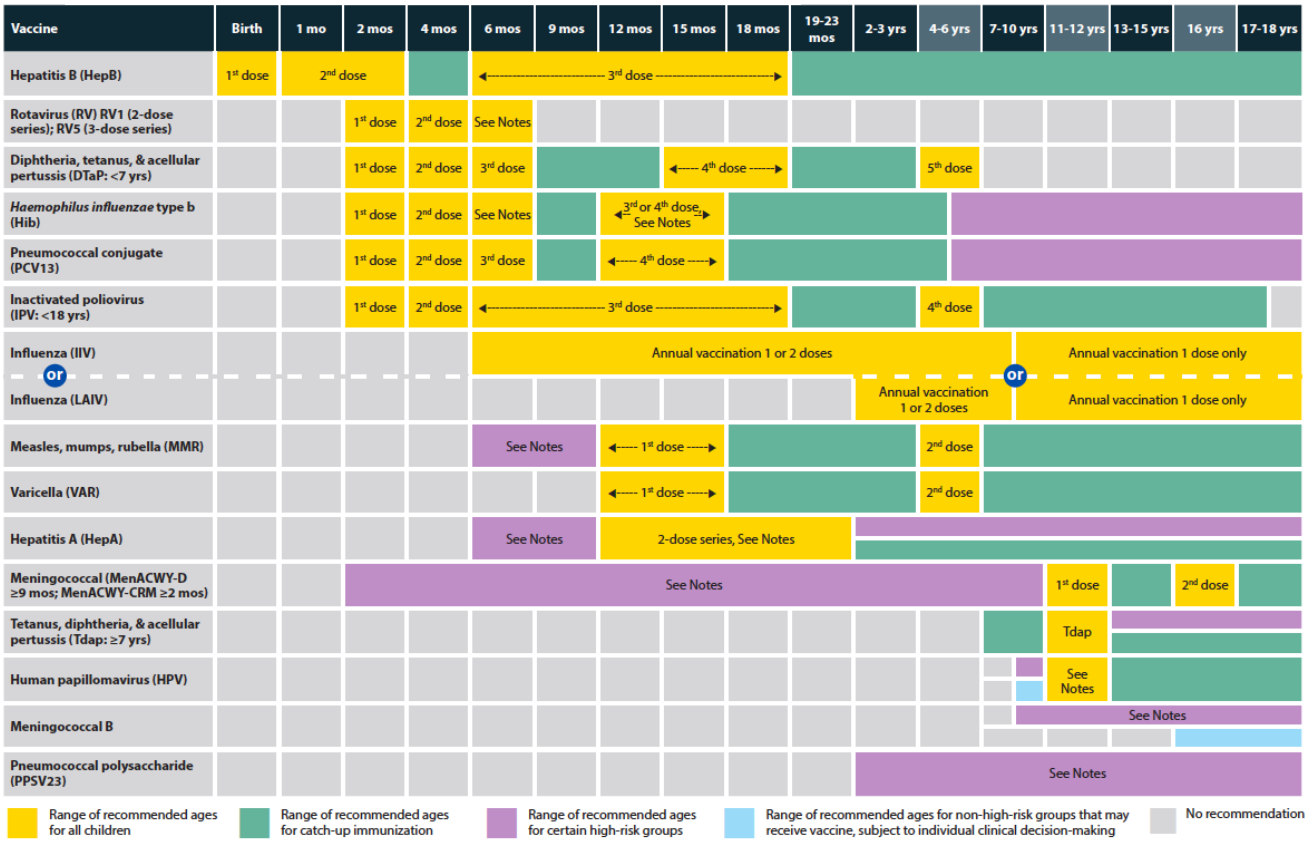

Figure 1: CDC Pediatric Vaccination Schedule Recommendation 2019

While the vaccination schedule is recommended at a national level, states are at liberty to write individualized requirements into law and determine how compliance is monitored. Kentucky children vaccine requirements are outlined in Kentucky Revised Statute (KRS) 214.034. Vaccine requirement schedules are outlined by the Cabinet for Health and Family Services (902 KAR 2:060 Immunization Schedules) and include requirements for diphtheria, tetanus, polio, pertussis, measles, rubella, mumps, hepatitis B, and haemophilis influenzae (KRS § 214.034).

Exemptions to vaccination requirements are listed in KRS § 214.036. The statute states that no vaccination or infectious disease testing should pose harm to a child based on

physician discretion or conflict with parent religious beliefs (KRS § 214.036). A child with medical contraindications to all or some vaccinations must obtain a certificate of medical exemption from the child's healthcare provider. A religious exemption certificate can be issued by a healthcare provider, pharmacist, local health department, other licensed healthcare facility upon receipt of a sworn statement from the parent or guardian (KRS § 214.036).

There are many different proposed barriers to vaccine compliance. Vaccine hesitancy, concern about side effects, objection to large numbers of injections, fear of autism, moral or religious objections, lack of access, and lack of information have been identified as likely barriers to vaccination (Ventola, 2016). A survey of parents, nurses, and pediatricians in thirty-two family practice clinics in Minnesota reported that the majority of both parents and pediatricians believe that three vaccines administered in one visit is too many for a child. In this survey most parents, nurses, and physicians (71%, 76%, and 59% respectively) think that three injections are too many for a child to receive at one visit (Madlon-Kay, 1994).

Varicella (Varivax®) and MMR (MMR II®) are two vaccinations recommended in children that are live attenuated vaccines (FDA, 2019). Live vaccines carry the potential risk of causing the disease they are intended to prevent and/or producing mild versions of the disease they are intended to prevent. (FDA, 2019). While the potential for infection from a live vaccine exists, the risk is exceedingly minimal in an immune competent host.

Although no data exist demonstrating that live vaccinations are more commonly refused by parents, they nationally have the lowest compliance rates in kindergarteners.

There are 120 counties in Kentucky. Health and socioeconomic factors such as income and education, vary greatly depending on location in the state (e.g., rural vs urban setting, total county population size). A general geographic pattern exists where more urban, highly populated counties have better health factor rankings. Health factor rankings in the state range from 1 to 120, with 1 indicating the best health and higher scores indicating worse health. (County Health Rankings, 2016). Health factors considered in this ranking include weighted scores for health behaviors, clinical care, social and economic factors, and physical environment and is created by county health rankings (County Health Rankings, 2016). Figure 2 shows the health factor county ranking for each Kentucky county. The four largest cities in Kentucky have been denoted with Frankfort being the

Figure 2

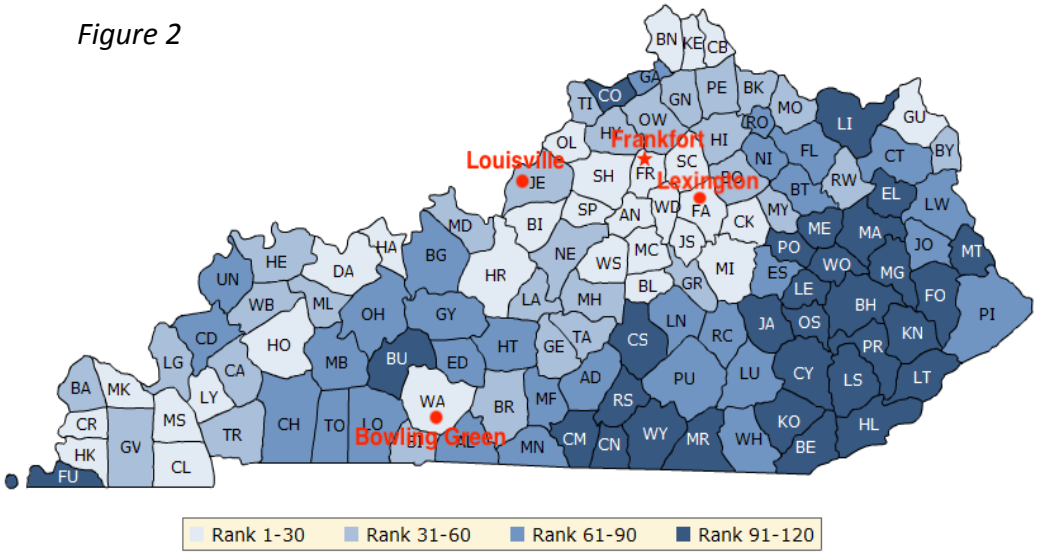

Figure 2: Kentucky Counties Ranked by Health Factors

capital. The county with the lowest population density is Hickman (HK) County (USA, 2019).

The Kentucky Immunization Program publishes an annual report of vaccine compliance for kindergarten and sixth grade aged children in the state broken down by county and school attended (Sands, 2017). In July of 2017, the 2015-2016 school year data were released. As of March 2019, the 2016-2017 data had not been released. The report contains data on the total number of children enrolled in kindergarten and sixth grade in each Kentucky county and school, as well as the number of exemptions on file and number of missing vaccination certificates. According to the annual report, Kentucky did not meet any of the HP 2020 kindergarten age target measures in 2015-16; statewide rates were reported at 94% four or more DTaP, 94.5% three or more polio, 94% three or more HepB, 92.3% two MMR, and 91.5% two Varicella (Sands, 2017).

Carroll county had the lowest compliance rates for both Polio (79.5%) and Varicella (71.9%), Mason county had the lowest compliance rates for MMR (81.6%) and HepB (75.6%), Garrard county had the lowest compliance rate for DTaP (77.5%), and Ohio county had the lowest overall vaccination rate at 85.5% (Sands, 2017). There were 128 (0.24%) kindergarten children with medical exemptions and 380 (0.74%) with documented religious exemptions of a total 2096 children (Sands, 2017). There were several counties with perfect kindergarten vaccine compliance: Adair, Fulton, Hickman, Jackson, Larue, Menifee, Nicholas, Pendleton, Russell, and Wolfe (Sands, 2017).

The purpose of this analysis is to assess the relationship between socioeconomic factors in Kentucky counties and vaccination rates in kindergarten children. Determining which socioeconomic factors are associated with vaccination rates can inform approaches aimed at increasing vaccine compliance at the county level. It is expected that counties with a higher percentage of uninsured children, higher percentages of children in poverty, higher percentages of unemployment, higher percentages of single parent households, lower higher school graduation rates, and lower rates of adults with at least some college education will correlate with lower county vaccination rates in kindergarten aged children.

II. Methods

Data collection

Vaccination statistics are reported in terms of total children in school, number of current certificates, medical exemptions, religious exemptions, and missing certificates. Each county and school report data for DTap, Polio, Hepatitis B, MMR, and Varicella vaccinations at the kindergarten and sixth grade level.

County health data are published annually and tracks many different aspects of county health outcomes and health factors including health behaviors, clinical care, social and economic factors, and physical environment. County health data are compiled from different sources that monitor the variables of interest. For this analysis number of children in poverty, number of adults unemployed, number of single parent households, high school graduation rate, and number of adults with at least some college education were utilized and converted to percentages (if not reported as such).

Data Analysis

In addition to descriptive statistics with two sample t-test, two additional sets of analysis were conducted. Pearson correlation was utilized to determine if significant relationships existed between county-level social and economic factor rankings and composite adjusted vaccination rates. The county-level social and economic factor ranking is calculated and reported as part of the county health rankings. The county ranking is produced from an adjusted z-score of social and economic factors defined as education, employment, income, family and social support, and community safety. The ranking is

state specific ranking the counties from 1-120 with 1 being the best combination of social and economic factors and 120 being the worst. Multivariate regression assessed the relationship between various vaccination rates (total vaccination average, DTaP, Polio, HepB, MMR, Varicella) and a variety of socioeconomic factors.

Table 1: Description of Statistical Models

Type of Model	Dependent Variable	Independent Variable
Correlation	Total kindergarten vaccination certificates (percent)	County-level social and economic factor ranking (combination of education, employment, income, family and social support and community safety)
Multivariate Regression	Total kindergarten vaccination rates (percent)	Percent of children uninsured, percent of children in poverty, unemployment rate, high school graduation rate, percent of adults with some college, percent of single-family households
Multivariate Regression	DTaP vaccination rate (percent)	
Multivariate Regression	Polio vaccination rate (percent)	
Multivariate Regression	Hepatitis B vaccination rate (percent)	
Multivariate Regression	MMR vaccination rate (percent)	
Multivariate Regression	Varicella vaccination rate (percent)	

Multicollinearity was assessed via variance inflation factor (VIF). It is generally accepted that multicollinearity becomes a consideration when the VIF is above 2.5 and a problem when the VIF is above 10 (Harp, 2018). For this analysis a cut-off of VIF 5 was utilized. Results showed that independent variables were not highly related with the highest VIF being 3.09 and the average VIF being 1.86.

III. Results

Descriptive statistics

Of the 120 counties in Kentucky, 48 (40%) of them met all five HP 2020 target vaccination rates and 72 (60%) missed at least one target. The most commonly missed target was Varicella with 47 counties failing to meet the vaccination target, a total of 1881 vaccinations short of the 95% compliance rate state wide. It is important to note that children who have had chickenpox were not accounted for. The MMR vaccination series was the next most commonly missed vaccination goal with 45 counties failing. Table 2 displays the averages of each county-level socioeconomic variable divided by the counties that met and failed to meet all of the HP 2020 targets. Analysis suggests that there are minimal average differences between these counties. Percent of children uninsured was lower and percent of adults with at least some college education was higher on average in the counties that did not meet all HP 2020 goals.

To determine if there was a significant difference between rates for each socioeconomic variable in counties that met and did not meet HP 2020 goal, a two-sample t-test were utilized. The t-tests showed that there was not a statistically significance in any of the socioeconomic variables in counties that met and did not meet all HP 2020 goals. Significance was set at $p < 0.05$.

Correlation

Pearson correlation analysis was utilized to compare the social and economic factor rank to the vaccination rate in each county. A correlation coefficient of -0.2372 shows an inverse relationship between vaccination rate and county rank. As county rank increases, where lower value denotes better ranking, the vaccination rate decreases ($p < 0.05$). The absolute value of 0.2372 is relatively small when considering that ± 1 denotes a perfect correlation and 0 no correlation at all.

Multivariate Regression

Multivariate regression models were used to assess the relationship between the independent variables (percent of children uninsured, percent of children in poverty, unemployment rate, high school graduation rate, percent of adults with at least some college, percent of single-family households) and average vaccination rate (combined) in addition to each vaccination rate individually.

Each regression model is assessed for statistical significance; average vaccination rates, DTaP vaccination rates, polio vaccination rates, MMR vaccination rates, and Varicella vaccination rates all reached significance at $p< 0.05$. (Tables 2-5, 7, 8) The only regression model that failed to reach $p< 0.05$ level of significance was Hepatitis B vaccination rates (prob > F = 0.0765), indicating the independent variables do not reliably predict these vaccination rates. (Table 6)

In the regression model (Table 3) examining the relationship between county-level socioeconomic factors and total vaccine compliance rate, only the percent of uninsured children reached significance. Specifically, for each percent increase in number of uninsured children in a county, the total vaccination compliance rate increased by 0.59% ($p<0.05$). The adjusted r-squared value for this regression was 0.060.

In the regression model (Table 4) examining the relationship between county-level socioeconomic factors and DTaP compliance rate, the high school graduation rate and the percent of adults with some college reached significance. For each percent increase in high school graduation rate the DTaP vaccination rate increased by 0.18% ($p<0.05$). For each percent increase in number of adults with some college the DTaP vaccination rate increased by 0.14% ($p<0.05$). The adjusted r-squared value for this regression was 0.074.

In the regression model (Table 5) examining the relationship between county-level socioeconomic factors and Polio compliance rate, the percent of children uninsured, high school graduation rate, and percent of adults with some college reached significance. For each percent increase in uninsured children the Polio vaccination rate increased by 0.70% ($p<0.05$). For each percent increase in high school graduation rate the Polio vaccination rate increased by 0.18% ($p<0.05$). For each percent increase in number of adults with some college the Polio vaccination rate increased by 0.14% ($p<0.05$). The adjusted r-squared value for this regression was 0.080.

In the regression model (Table 7) examining the relationship between county-level socioeconomic factors and MMR vaccination compliance rate, the percent of children uninsured was the only variable to reach significance. For each percent increase in children uninsured the MMR vaccination compliance rate increased by 0.95 ($p<0.05$). The adjusted r-squared value for this regression was 0.060.

In the regression model (Table 8) examining the relationship between county-level socioeconomic factors and Varicella vaccination compliance rates, the percent of children uninsured was the only variable to reach significance. For each percent increase in children uninsured the Varicella vaccination compliance rate increased by 0.98% ($p<0.05$). The adjusted r-squared value for this regression was 0.062.

IV. Discussion

Results from this analysis showed that fewer than half (40%) of the Kentucky counties met all HP 2020 vaccination targets for kindergarten children. Of the 54,075 children enrolled in public kindergarten during the 2015-16 school year, 51,471 (95.2%) were vaccine compliant. Counties that did not meet HP 2020 in at least one vaccination category were statistically no different than counties that met all HP 2020 goals in terms of rate of uninsured children, unemployment rate, high school graduation rate, percent of adults with some college, and percent of single-parent households.

There was a correlation between counties with better (closer to 1) social and economic factor rankings having lower vaccination rates. These counties are likely not being targeted for health services. It is possible that these counties are not receiving the attention to help improve vaccination rates as counties who have a lower social and economic factor ranking. I hypothesized that higher county health ranking would correlate with better overall vaccination rates as there is better health literacy and access in these counties.

There have been studies in many different settings and countries showing that increased education level leads to higher vaccination compliance rates. This analysis only saw such a relationship with DTaP and Polio vaccination rates increasing with increasing county-level education rates. As high school graduation rate and percent of adults with some college increased DTaP and Polio vaccination rates increased as well.

Analysis showed that Varicella, MMR, Polio, and total average vaccination compliance was significantly related to percent of uninsured children. As percent of uninsured children increased so did the vaccination compliance rate. A possible explanation for this is that Kentucky runs a Vaccines for Children Program that provides vaccinations to children who are either uninsured or low income (CDC, 2016). The Vaccines for Children program is federally funded and conducted by the CDC. Children are eligible if they are Medicaid eligible or enrolled, lack insurance, or underinsured (insurance that does not cover vaccinations).

This analysis did not find any significant relationship between unemployment rate or percent of single-family households and any vaccination compliance rates. This did not support my hypothesis that unemployment would be associated with lower vaccination rates as these families likely would not be focused on pediatric care visits and vaccinations.

There is not clear data on how the “anti-vaxx” movement is affecting vaccination rates across the country. A study in California showed that personal belief-based exemptions were highest in white, affluent families. The study did not find a significant relationship between higher education and anti-vax beliefs (Yang, 2016). Another study showed that under-vaccinated and unvaccinated children tend to come from different family demographics (Smith, 2004). Under-vaccinated children tend to come from families without the means (single-parent, at or below the poverty line, and no college education) where unvaccinated children tend to come from families with annual income greater than

$75,000 and the parents believe vaccines are unsafe.

In recent months there have been multiple Measles outbreak across the county (CDC, April 2019). From January through April 11th of 2019 there have been 555 reported cases of the measles in 20 different states; Arizona, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Nevada, New Hampshire, New Jersey, New York, Oregon, Texas, and Washington. (CDC, April 2019). The CDC has attributed the outbreaks to infected individuals coming into the United States from counties experiencing outbreaks and spread has been exacerbated by unvaccinated individuals. Counties with exceptionally low MMR vaccination rates are at highest risk of an outbreak if exposed.

Limitations

The most recent data were not available at the time of analysis. Based on previous publication dates the 2016-2017 school year data should have been available but it has not yet been released. To accommodate the older school vaccination survey data, 2016 county health data was utilized. There was likely not a significant difference between the data but that cannot be known.

Without individual kindergarten student survey data all analyses are at the county level. Working at the county level generalizes the data across the population and may not necessarily be representative of individuals within each county. The vaccination data is not specific in why children are unvaccinated. Without details of parent objection or

barrier to vaccination interventions to improve compliance cannot be exact.

Recommendations

This analysis should be utilized as a guide for programs working to improve vaccination compliance. Utilization of this analysis provides clear target populations and counties where best practices to improve vaccine compliance should be implemented. Counties that missed at least one HP 2020 goal should be targeted as there is clear room for improvement in these counties.

It is important to ensure that all counties, even those with higher social and economic rankings receive public health attention. The correlation shown between higher social and economic factor ranking and lower vaccination rate shows that there has likely been more of a focus on populations who may not have obvious access to vaccine and a lack of education and focus on communities who have more direct access to care.

Future research in this area should be conducted to analyze the cause of vaccine noncompliance. This study has provided a generalized view of how socioeconomic factors interact with vaccine compliance but there is likely also a choice or belief element playing a role in compliance.

Conclusion

This analysis shows that there are many compounding factors and barriers to childhood vaccination rates. While one socioeconomic factor may have a significant relationship with certain vaccination it cannot be shown to have significant impact on others. Although factors impacting specific vaccines varies, we were able to show that there is a significant relationship between socioeconomic factors and vaccination compliance rates. The results of this analysis should be utilized to target populations for vaccine compliance improvement. Such targeting should match best practices for increasing vaccine compliance.

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Appendices

Table 2: Descriptive Statistics Analysis

County-level Socioeconomic Variable	Counties that met Healthy People 2020 goals for all vaccines (48 counties)	Counties that missed at least one Healthy People 2020 target (72 counties)	Two sample T-test p-value
Percent of children uninsured	7.53%	7.2%	0.144
Percent of children in poverty	29.98%	30.3%	0.698
Unemployment rate	7.59%	7.59%	0.655
High school graduation rate	91.7%	90.2%	0.128
Percent of households that are single parent	31.6%	33.2%	0.065
Percent of adults with some college	49.48%	50.6%	0.568
Mean social and economic factor ranking	Average 59 Range 1- 119	Average 61 Range 6- 120	

Table 3: Multivariate Regression All vaccinations

Total percent	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.589	0.048	0.0066 – 1.172
Percent of children in poverty	0.018	0.787	- 0.1122 – 0.1477
Unemployment rate	- 0.075	0.780	- 0.6048 – 0.4552
High school graduation rate	0.134	0.078	- 0.0154 – 0.2842
Percent of adults with some college	0.086	0.105	- 0.1832 – 0.1908
Percent of single-family households	-0.0001	0.998	- 0.1094 – 0.1091
Constant	74.64	0.000	57.45 – 91.85
Observations = 120 Adjusted R-squared = 0.06		F = 2.27 Prob > F = 0.042	

Table 4: Multivariate Regression DTaP vaccinations

DTaP	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.379	0.062	- 0.0335 – 1.391
Percent of children in poverty	0.052	0.519	- 0.1070 – 0.2106
Unemployment rate	0.012	0.971	- 0.6359 – 0.6594
High school graduation rate	0.193	0.039	0.0103 – 0.3766
Percent of adults with some college	0.142	0.030	0.0141 – 0.2696
Percent of single-family households	-0.034	0.616	- 0.1674 – 0.0996
Constant	64.13	0.000	43.12 – 85.15
Observations = 120 Adjusted R-squared = 0.074		F = 2.57 Prob > F = 0.022	

Table 5: Multivariate Regression Polio Vaccinations

Polio	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.704	0.046	0.013 – 1.395
Percent of children in poverty	0.059	0.451	- 0.095 – 0.213
Unemployment rate	- 0.041	0.896	- 0.669 – 0.587
High school graduation rate	0.1795	0.048	0.002 – 0.357
Percent of adults with some college	0.1396	0.028	0.016 – 0.264
Percent of single-family households	- 0.037	0.576	- 0.166 – 0.928
Constant	65.96	0.000	45.58 – 86.34
Observations = 120 Adjusted R-squared = 0.0797		F = 2.72 Prob > F = 0.017	

Table 6: Multivariate Regression HepB Vaccinations

HepB	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.663	0.073	- 0.062 – 1.389
Percent of children in poverty	0.042	0.608	- 0.119 – 0.204
Unemployment rate	- 0.041	0.903	- 0.700 – 0.619
High school graduation rate	0.157	0.097	- 0.029 – 0.344
Percent of adults with some college	0.110	0.096	- 0.019 – 0.241
Percent of single-family households	- 0.036	0.605	- 0.172 – 0.100
Constant	69.83	0.000	48.42 – 91.24
Observations = 120 Adjusted R-squared = 0.0464		F = 1.96 Prob > F = 0.0765	

Table 7: Multivariate Regression MMR Vaccinations

MMR	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.950	0.030	0.092 – 1.808
Percent of children in poverty	0.053	0.583	- 0.138 – 0.245
Unemployment rate	- 0.054	0.890	- 0.835 – 0.726
High school graduation rate	0.197	0.606	- 0.024 – 0.417
Percent of adults with some college	0.115	0.080	- 0.386 – 0.269
Percent of single-family households	- 0.042	0.140	- 0.203 – 0.119
Constant	62.34	0.000	37.02 – 87.67
Observations = 120 Adjusted R-squared = 0.06		F = 2.27 Prob > F = 0.042	

Table 8: Multivariate Regression Varicella Vaccinations

Varicella	Coefficient	P-Value	[95% Conf. Interval]
Percent of children uninsured	0.981	0.038	0.53 – 1.909
Percent of children in poverty	0.103	0.324	- 0.104 – 0.310
Unemployment rate	0.013	0.976	- 0.831 – 0.857
High school graduation rate	0.223	0.067	- 0.016 – 0.462
Percent of adults with some college	0.162	0.057	- 0.049 – 0.328
Percent of single-family households	- 0.060	0.493	- 0.234 – 0.114
Constant	55.28	0.000	27.89 – 82.66
Observations = 120 Adjusted R-squared = 0.062		F = 2.31 Prob > F = 0.038	

Biographical Sketch

Abigail Wiggins recently completed her Master of Public health degree with a concentration in Population Health Policy & Management at the University of Kentucky. Abigail completed her Doctor of Pharmacy degree at the same time at University of Kentucky. Abigail is headed to Piedmont Regional Midtown to complete a PGY1 Pharmacy residency. Abigail can be reached at abbywiggins428@gmail.com.