# RETROSPECTIVE IMMUNIZATION COVERAGE SURVEY

## 2006- 2007 Results (School Year 2010-11)

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## ACRONYMS

| | |
|---|---|
| CI | Confidence interval |
| HP2010 | Healthy People 2010 |
| KCI | Kansas Certificate of Immunizations |
| KDHE | Kansas Department of Health |
| KSDE | Kansas State Department of Education |

## VACCINE ACRONYMS

| | |
|---|---|
| DTaP4 | 4 doses of diphtheria and tetanus toxoids and acellular pertussis vaccines including diphtheria and tetanus toxoids (DTaP/DT) vaccine |
| HepB3 | 3 doses of hepatitis B vaccine |
| Hib3 | 3 doses of *Haemophilus influenzae* type b vaccine |
| MMR1 | 1 doses of measles, mumps, and rubella vaccine |
| PCV3 | 3 doses of pneumococcal conjugate vaccine |
| Polio3 | 3 doses of polio vaccine |
| Var1 | 1 dose of varicella vaccine |
| 4-3-1-3-3 | DTaP4-Polio3-MMR1-Hib3-HepB3 |
| 4-3-1 | DTaP4-Polio3-MMR1 |

# EXECUTIVE SUMMARY

Overview

The Kansas Certificates of Immunizations (KCIs) and other immunization records for children enrolled in a kindergarten class in Kansas public and private schools during the 2010-2011 school year were collected and evaluated for immunization coverage levels. Children born between September 2, 2004 and September 1, 2005 were included in this study, and their immunization coverage levels at 24 months of age which corresponds to September 2, 2006 and September 1, 2007 were analyzed. The results for this survey were measured against similar previous studies. In total, there were 792 schools, 690 public and 102 private, included in the analysis, which consisted of a representative sample of 12,912 children from both public and private schools.

Coverage at 24 Months of Age

The statewide coverage level for the 4-3-1-3-3 series (DTaP4, Polio3, MMR1, Hib3, and HepB3) for children by 24 months of age was 71.5% and did not increase, compared to the 2009-2010 Retrospective Study, and remains below the Healthy People 2010 goal of at least 80%. Hib3, which had a coverage level of 87.8%, is the only vaccination of the 4-3-1-3-3 series that increased significantly from the previous year's study. Varicella vaccination, which has been required for school entry since the 2005-06 school year, increased significantly to 85% by 24 months of age. The coverage levels for PCV3, which is not required for school entry, increased significantly by more than 10 percentage points to 81%.

The 105 counties were grouped into 3 categories based on population density, and coverage levels were compared among these groups (Appendix 1). Counties that were "sparsely populated" (<20 persons per square mile) had higher coverage levels for the 4-3-1-3-3 series (77.7%) than "moderately populated" (20 – 149.9 persons per square mile, 72%) and "urban" (≥150 persons per square mile, 69.8%) counties. DTaP4, Polio3, MMR1, and HepB3 showed no significant variation in coverage levels between population density groups. Two counties had 100% coverage for all vaccinations; both were sparsely populated (Appendix 2).

# RETROSPECTIVE IMMUNIZATION COVERAGE SURVEY 2006-2007 (SCHOOL YEAR 2010-2011)

## INTRODUCTION

### Objective
This study was conducted to estimate the immunization coverage levels of children at 24 months of age.

### Study Population
The study population included a representative sample of all kindergarten students enrolled in both public and private schools in the 2010-11 school year.

### Study Design
A stratified, cross-sectional design was utilized for this study, with each county representing a stratum. The characteristics of interest, or outcome variables, were the percentages of children who were immunized against diphtheria, tetanus, pertussis, polio, measles, mumps, rubella, *Haemophilus influenzae* type b, hepatitis B virus, varicella, and pneumococcal disease. Vaccination coverage was assessed for these children at 24 months of age.

Immunization coverage levels were measured for single vaccinations and combinations of vaccinations according to the recommended immunization schedule for children by 24 months of age (Appendix 4).[1] ***The results of the survey refer to children who were born between September 2, 2004 and September 1, 2005. The coverage levels refer to the point in time at which these children turned 24 months old, between September 2, 2006 and September 1, 2007.***

## METHODS

### Sampling Techniques
A probability sample of all children enrolled in Kansas public school kindergartens was drawn. To ensure an adequate sample size in each county and to maximize the efficiency of the sampling process, a different sampling ratio was established for each county, and a probability sample was selected using a systematic sampling technique. Due to the small size of the private school population in Kansas, all records from private schools were solicited.

### Data Collection
All Kansas public and private schools with a kindergarten class received a letter, co-signed by officials representing the Kansas Department of Health and Environment (KDHE) and the Kansas State Department of Education (KSDE), requesting their participation in the survey. The letters sent to public schools specified the number of records required to generate estimates of county-specific immunization coverage levels and outlined the process of systematically selecting a probability sample of records. The study coordinator at each school (typically the school nurse) was instructed to select all kindergarten exemptions for submission to KDHE, then, depending on the calculated sampling ratio for their county,

[1] The Recommended Immunization Schedule used, as reference for ages and immunization in this paper was the schedule approved by the Advisory Committee on Immunization Practices (ACIP), the American Academy of Pediatrics (AAP) and the American Academy of Family Physicians (AAFP) for the year 2005.

proceed to select all, every other, every third, every sixth, every eighteenth, or every nineteenth immunization record regardless of the size of the kindergarten class at that school. The private schools were instructed to select all immunization records (including exemptions). Children who were exempt from immunizations were excluded from the sampling.[2] The schools were informed they could submit KCIs or any other form of immunization record, including printouts from computerized record keeping programs. The study coordinators were also advised to remove all personal identifiers, except date of birth, to ensure confidentiality. Copies of the immunization records, exemption records, the current total number of kindergarten enrollees, the total number of exemptions and the number of exemptions sent for both medical and religious exemption in each school were forwarded to KDHE.

**Data Analysis**

In the 2010-11 survey, the analysis method changed from previous years. In the current study, only non-exempt children were included in the analysis of immunization coverage levels. Exemption status was determined through examination of records sent by schools. If a child was exempt from any of the immunizations, they were excluded from the analysis. Consistent with studies from the 2006-07 Retrospective Survey onward, children who had a date of birth recorded on the Kansas Certificate of Immunizations (KCI) or other data source and were the appropriate age for the analysis were included in the denominator. Point estimates of coverage levels and 95% confidence intervals (95% CI) for DTaP4, Polio3, MMR1, Hib3, HepB3, 4-3-1 series, 4-3-1-3-3 series, Var1, and PCV3 vaccinations were calculated. A child was considered up-to-date for single vaccinations if, at 24 months of age, he or she had received at least four doses of DTaP (DTaP4), three doses of polio (Polio3), one dose of measles, mumps, and rubella (MMR1), three doses of *H. influenzae* type b (Hib3), three doses of hepatitis B (HepB3), one dose of varicella (Var1) vaccine, or three doses of pneumococcal conjugate (PCV3). A child was considered up-to-date for the 4-3-1 series if he or she was up-to-date for DTaP4, Polio3, and MMR1 vaccinations, and up-to-date for the 4-3-1-3-3 series if he or she was up-to-date for DTaP4, Polio3, MMR1, Hib3, and HepB3 vaccinations. Approximately 1% of children in the study had a history of varicella recorded on their immunization record. All children who indicated a history of varicella were included in the denominator, but only those who reported history of vaccination were included in the numerator. This methodology was performed because the date of disease was frequently not recorded, thus it could not be determined at what age the child had varicella.

Analyses were performed using weighted data and accounted for the complex sample design effect due to the stratification process and differences in sampling ratios between counties.[3] Sample weights were calculated using the number of kindergartners enrolled in a county and the number of records analyzed for that county.

All population and birth cohort data was calculated from the 2005 Annual Summary of Vital Statistics.[4] The 105 counties were categorized based on population densities, and for the purpose of this analysis, counties were grouped into "urban," "moderately populated," and "sparsely populated" (Appendix 1). Immunization coverage level estimates were compared among these groups.

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[2] To simplify the selection of immunization records, each study coordinator was asked to select all exemptions and then sample the remaining kindergarten immunization records according to the county's sampling scheme. This allowed for a simpler method of record keeping and shipment of immunization records to KDHE.

[3] Complex survey design effect was accounted for by using the SAS Procedure PROC SURVEYFREQ.

[4] 2005 Annual Summary of Kansas Vital Statistics (http://www.kdheks.gov/ches).

The results from this survey were compared with the results from the 2007 National Immunization Survey (NIS).[5,6] Data for the population-based NIS are collected by the Centers for Disease Control and Prevention (CDC) through a telephone survey of randomly selected households. For accuracy, healthcare providers of children included in the survey are contacted by mail.

## RESULTS

### Data Collection

Letters of invitation to participate in the survey were sent to 856 Kansas schools; of these, 738 were public schools and 118 were private. Twenty-six schools reported not having a kindergarten class for the 2010-2011 school year and 30 did not respond. Immunization data were received from 800 schools (698 public schools and 102 private schools) with kindergarten classes, corresponding to a school participation of 96.4%. In total, 792 schools were included in the analysis (690 public schools and 102 private schools). KCIs from eight schools were not included in the analysis because the dates of birth had been removed.

The number of children enrolled in kindergarten at the public and private schools that submitted immunization data were 38,496, which is 97% of the 39,701 children in that birth cohort. The children in the birth cohort that did not participate in the study include children who are home schooled or attend other special schools as well as those enrolled in schools that did not participate in the study. The number of immunization records received was 15,744, which is equivalent to one child selected for every 2.5 children enrolled. The range of the sample size by county was from 6 to 1,124 records while the range of student enrollment was from 6 to 7,684.[7]

Of the 15,744 immunization records returned and examined, 14,932 (95%) had readable birth dates and immunization dates. Seventy-seven percent of schools submitted KCIs, while 17% submitted printouts from a computerized record keeping program, and 6% of the schools submitted a combination of the two types of records. For the 24 month old analysis, 12,912 (86%) children were included in the analysis because they were 24 months of age between September 2, 2006 and September 1, 2007.

The number of records included in the analysis by population density were: 3,691 (28.6% of all records used, representing 12.7% of the population after weighting) in sparsely populated, 5,920 (45.9% of all records used, representing 33.5% of the population after weighting) in moderately populated, and 3,301 (25.6% of all records used, representing 53.8% of the population after weighting) in urban counties. The birth cohort across the state of Kansas is 10.5% in sparsely populated, 34.4% in moderately populated and 55.1% in urban counties.[8]

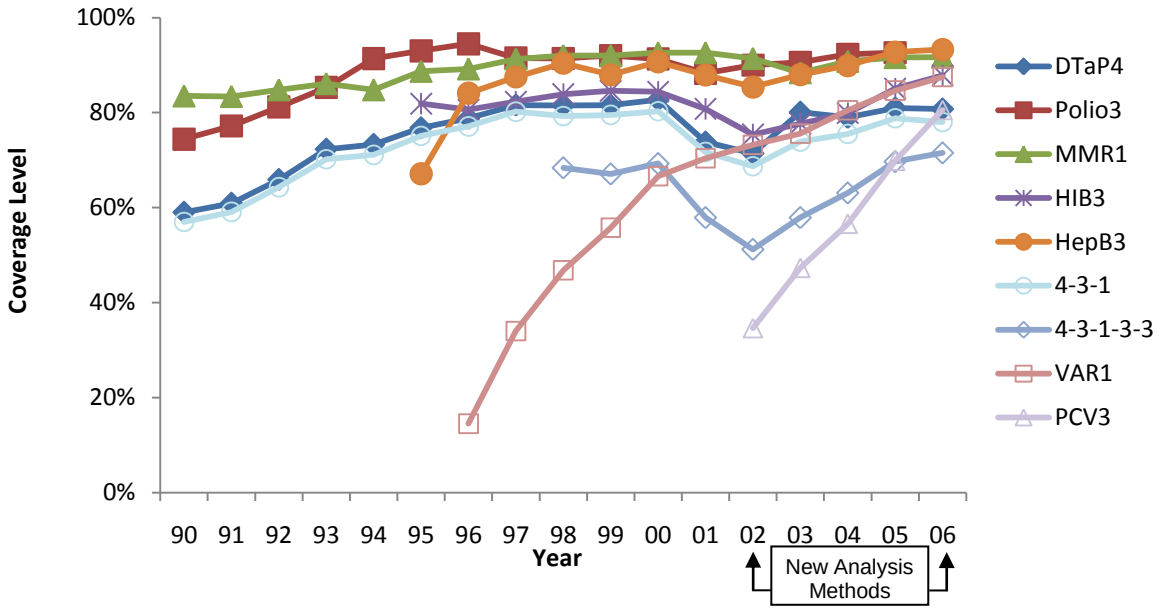
### Statewide Immunization Coverage by Age 24 Months

The immunization coverage levels for three vaccinations (Hib3, Var1, and PCV3) significantly increased compared to coverage levels from the previous year's retrospective study with the PCV3 vaccination coverage estimate increasing by more than 10 percentage points from last year. Vaccination

[5] http://www.cdc.gov/vaccines/stats-surv/nis/default.htm#nis
[6] Children in the 2007 NIS were born between January 2004 and July 2006
[7] Estimates from counties with small sample size (<50) may be unstable and changes over time should be interpreted with caution
[8] Numbers are rounded

coverage for the remaining immunizations (DTaP4, Polio3, MMR1, HepB3) remained unchanged (Figure 1). The immunization coverage level for 4-3-1-3-3 was 71.5%, which was not significantly greater than last year's estimate (Table 1).

**FIGURE 1: Immunization coverage levels at 24 months of age by vaccine, Kansas 1990 - 2006.***




* Based on retrospective surveys from school years starting in 1994 through 2010

**TABLE 1: Immunization coverage levels at 24 months of age by vaccine, Kansas 2006-2007.***

| | Percent (%) † | 95% CI† |
|---|---|---|
| DTaP4 | 80.8 | 79.7 - 81.9 |
| Polio3 | 92.6 | 91.9 - 93.4 |
| MMR1 | 91.7 | 90.9 - 92.5 |
| Hib3 | 87.8§ | 86.9 - 88.8 |
| HepB3 | 93.3 | 92.6 - 94 |
| 4-3-1 Series | 78.0 | 76.8 - 79.2 |
| 4-3-1-3-3 Series | 71.5 | 70.3 - 72.8 |
| Var1 | 87.5§ | 86.6 - 88.4 |
| PCV3 | 80.6§ | 79.5 - 81.6 |

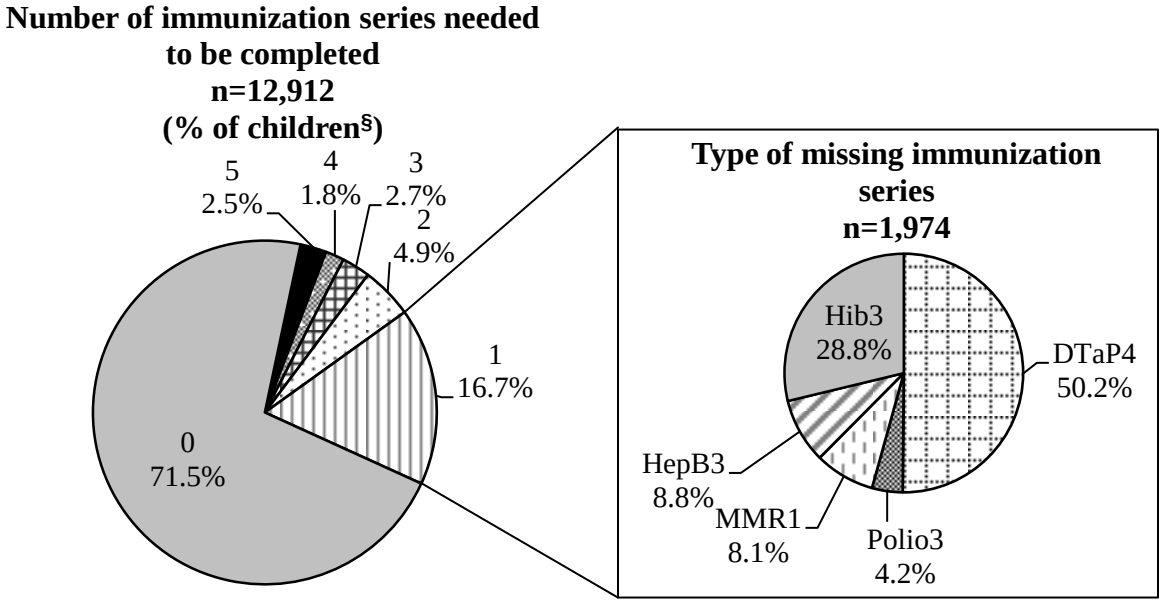
* Based on the retrospective survey for the school year starting 2010

† Percentage up-to-date and 95% confidence interval

§ Statistically significant compared to retrospective study 2009-2010

Of the children missing one or more series of the 4-3-1-3-3 at 24 months of age, 58.7% (16.7% of total population studied) needed to complete one immunization series (DTaP4, Polio3, MMR1, Hib3, *or* HepB3) (Figure 2). If these children had received the missing immunization series, the coverage levels for 4-3-1-3-3 would have increased from 69.7% to 88.2%. Among children who needed one immunization series, the majority (50.2%) needed DTaP4. Of children not up-to-date at 24 months of age, 8.6% (2.5% of total population studied) were not up-to-date on any of the vaccination series (DTaP4, Polio3, MMR1, HepB3 and Hib3).

**FIGURE 2: Number and type of immunization series children at 24 months of age needed to be up-to-date for the 4-3-1-3-3, Kansas 2006 - 2007.***




*Based on the retrospective survey for the school year starting 2010

§Percentages based on weighted frequencies.

**County-level Immunization Coverage of Children at 24 Months of Age**

Immunization coverage was also analyzed at the county level. The number of counties meeting the Healthy People 2010 goal for individual vaccinations varied greatly with only 19 counties having 90% coverage or better for DTaP4 while 96 counties had 90% coverage or better for HepB3 (Table 2).[9] Two counties, Wichita and Wallace, reached 100% coverage for all immunizations; both of these counties are sparsely populated. All vaccination coverage levels are displayed by county in Appendix 2.

**TABLE 2: Number of Kansas counties meeting the Healthy People 2010 goals for 2006-2007.***

| | Number of counties (n = 105) |
|---|---|
| DTaP4 | 19 |
| Polio3 | 92 |
| MMR1 | 88 |
| Hib3 | 68 |
| HepB3 | 96 |
| 4-3-1-3-3 Series | 46 |
| Var1 | 44 |
| PCV3 | 33 |

* Based on the retrospective survey for the school year starting 2010

Counties were classified based on their population densities, and coverage levels were compared among the three categories (Table 3). Counties that were sparsely populated had significantly higher coverage

[9] Healthy People 2010 set goals of 90% coverage for DTaP4, Polio3, MMR1, Hib3, HepB3, and Var1 and 80% coverage for 4-3-1-3-3 series among children aged 19 to 35 months.

levels for the 4-3-1-3-3 series than counties with greater population densities (moderately populated and urban). Sparsely populated counties had significantly greater vaccination coverage levels for the 4-3-1 series compared to moderately populated counties, but there was no difference when compared to urban counties. The only other vaccination that had significantly different coverage levels was Hib3, with sparsely populated counties having higher coverage than urban counties.

**TABLE 3: Kansas immunization coverage levels by peer group for 2006-2007.***

| Counties by Population Density – Condensed Groups n=12,912 | | | |
|---|---|---|---|
| | **Sparsely Populated n=3,691 % (95% CI)** | **Moderately Populated n=5,920 % (95% CI)** | **Urban n=3,301 % (95% CI)** |
| DTaP4 | 82.1 (80.3 - 83.8) | 79.1 (78 - 80.3) | 81.5 (79.6 - 83.3) |
| Polio3 | 93.5 (92.2 - 94.7) | 93.0 (92.3 - 93.8) | 92.2 (90.9 - 93.4) |
| MMR1 | 92.3 (91.0 - 93.7) | 91.9 (91.1 - 92.7) | 91.4 (90.1 - 92.8) |
| Hib3 | 90.9 (89.5 - 92.3) | 88.6 (87.8 - 89.5) | 86.6 (85.0 - 88.2) |
| HepB3 | 94.2 (93.0 - 95.4) | 94.0 (93.3 - 94.6) | 92.6 (91.4 - 93.9) |
| 4-3-1 Series | 80.8 (79.0 - 82.5) | 77.0 (75.9 - 78.2) | 78.0 (75.9 – 80.0) |
| 4-3-1-3-3 Series | 77.7 (75.8 - 79.6) | 72.0 (70.8 - 73.2) | 69.8 (67.6 – 72.0) |
| Var1 | 85.8 (84.1 - 87.4) | 86.5 (85.6 - 87.5) | 88.5 (86.9 – 90.0) |
| PCV3 | 80.7 (79.0 - 82.5) | 80.2 (79.1 - 81.3) | 80.8 (78.9 - 82.6) |

* Based on the retrospective survey for the school year starting 2010

**National Immunization Survey (NIS) Coverage at 24 Months of Age**

Comparison of Kansas NIS results for immunization coverage at 24 months of age with results from the current retrospective study shows significant coverage differences in both Hib3 and PCV3 (Table 4).[10] The other immunization estimates (DTaP4, Polio3, MMR1, HepB3, 4-3-1 series, 4-3-1-3-3 series and Var1) did not vary significantly between the two surveys. The US National immunization coverage measured by NIS was significantly higher than the vaccination coverage levels measured by the retrospective study for Hib3, 4-3-1-3-3 series and PCV3.

**TABLE 4: Kansas and US National immunization coverage levels at 24 months of age.**

| | **Retrospective Study* % (95% CI)** | **Kansas NIS§ % (95% CI)** | **US National NIS§ % (95% CI)** |
|---|---|---|---|
| DTaP4 | 80.8 (79.7 - 81.9) | 84.7 (79.6 - 89.8) | 81.1 (80.1 - 82.1) |
| Polio3 | 92.6 (91.9 - 93.4) | 95.3 (92.5 - 98.1) | 91.2 (90.4 - 92.0) |
| MMR1 | 91.7 (90.9 - 92.5) | 92.1 (88.4 - 95.8) | 91.1 (90.4 - 91.8) |
| Hib3 | 87.8 (86.9 - 88.8) | 93.0 (89.4 - 96.6) | 91.8 (91.1 - 92.5) |
| HepB3 | 93.3 (92.6 - 94.0) | 93.9 (90.7 - 97.1) | 91.8 (91.1 - 92.5) |
| 4-3-1 Series | 78.0 (76.8 - 79.2) | 82.1 (76.6 - 87.6) | 79.0 (77.9 - 80.1) |
| 4-3-1-3-3 Series | 71.5 (70.3 - 72.8) | 78.4 (72.6 - 84.2) | 76.4 (75.3 - 77.5) |
| Var1 | 87.5 (86.6 - 88.4) | 88.3 (84.2 - 92.4) | 89.2 (88.4 - 90.0) |
| PCV3 | 80.6 (79.5 - 81.6) | 87.3 (82.8 - 91.8) | 89.3 (88.5 - 90.1) |

* Based on the retrospective survey for the school year starting 2010

§Based on 2007 NIS

[10] http://www.cdc.gov/vaccines/stats-surv/nis/data/tables_2007.htm

## DISCUSSION

Statewide immunization coverage levels at 24 months of age remained relatively unchanged for all but 3 vaccinations (Hib3, Var1, and PCV3). Because neither Hib3 nor PCV3 are required for school entry, and may not always be recorded on the school immunization document, the increase in coverage levels for these two vaccinations may reflect an improvement in the recording of these immunizations as opposed to an increase in vaccination coverage.

Polio3, MMR1, and HepB3 were the only vaccinations that met the Healthy People 2010 goal of at least 90% coverage. DTaP4 immunization coverage levels were the farthest from meeting the HP2010 goal with a coverage level of 80.8%. The 4-3-1-3-3 series remains more than seven percentage points from meeting the HP2010 goal of 80% coverage. Of the children who were not up to date for the 4-3-1-3-3 series, missing DTaP4 series accounted for the majority. However, the 4-3-1-3-3 HP2010 goal would have exceeded (88.2%) if children missing only one vaccination series, either DTaP4, Polio3, MMR1, Hib3 or HepB3, were up-to-date.

Forty-six counties (representing 16% of the birth cohort) reached the HP2010 goal of at least 80% coverage for the 4-3-1-3-3 series. The HP2010 goals for other childhood vaccines is 90% coverage or greater. For DTaP4, 19 counties (representing 5% of the birth cohort) met the HP2010 goal, while 92 counties (representing 87% of the birth cohort) had 90% coverage or greater for Polio3 and 96 counties (representing 95% of the birth cohort) met the HP2010 coverage goal for HepB3. For MMR1, 88 counties (representing 91% of the birth cohort) had vaccination coverage meeting the HP2010 goal, and for Hib3, 68 counties (representing 48% of the birth cohort) had coverage of at least 90%. Forty-four counties (representing 35% of the birth cohort) had 90% or greater coverage for Var1.

The coverage level estimates were compared to determine if variations exist among counties of different population densities. For the 4-3-1-3-3 series, the coverage level of sparsely populated counties, which only accounts for 12.7% of the population surveyed, was statistically higher compared to moderately populated and urban counties. Due to a lack of demographic data collected on children included in the survey, analyses could not be performed to determine contributing factors for this result. However, previous studies have similarly found immunization coverage to be lower in urban and inner-city settings than rural settings; this has been associated with lower socio-economic status of those living in urban settings.[11] Due to the large percentage of the population living in the 5 urban counties (53%), targeting this population to improve vaccination coverage would increase statewide immunization coverage levels.

The western half of the state had the largest number of counties with high immunization levels (90% or greater) for Hib3 (Appendix 3). Additionally, this region also had a large number of counties with 80% coverage or greater for the 4-3-1-3-3 series. The western part of the state is comprised of predominantly sparsely populated counties, which is consistent with the significantly higher coverage level for the 4-3-1-3-3 series and Hib3 between sparsely populated counties and those with greater population densities.

[11] Williams I, Milton J, Farrell J, Graham N. 1995. Interaction of Socioeconomic Status and Provider Practices as Predictors of Immunization Coverage in Virginia Children. Pediatrics. 96(3): 439-446; Feldman S, Andrew M, Gilber J, Bracken B, Thompson E. 1994. Measles Immunization of 2-Year-Olds in a Rural Southern State. JAMA. 271: 1417-1420.

The coverage level for the 4-3-1-3-3 series is lower in the 2010-11 Retrospective Survey (71.5 [95% CI 70.3 – 72.8]) when compared to the NIS 24 month milestone (78.4 [95% CI 72.6-84.2]) for Kansas; however, the coverage levels are not statistically different. Hib3 and PCV3 were significantly lower in the retrospective study compared to the KS NIS coverage. One potential reason for the differences in coverage levels could be due to Hib3 not being required for school entry and thus may not be routinely recorded on school immunization records; this is evidenced by no significant difference between the retrospective study and NIS for immunizations required for school entry. Additionally, NIS results for Kansas are not significantly different than the national NIS 4-3-1-3-3 coverage level (76.4 [95% CI 75.3-77.5]).

Vaccine coverage is of great public health importance. By having greater vaccination coverage, there is an increase in herd immunity, which leads to lower disease incidence and an ability to limit the size of disease outbreaks. In 2006, a widespread outbreak of mumps occurred in Kansas and across the United States. Prior to the outbreak, the incidence of mumps was at a historical low, and even with the outbreak, mumps disease rates were lower than in pre-vaccination era. Due to high vaccination coverage, tens or hundreds of thousands of cases were possibly prevented.

However, due to unvaccinated and undervaccinated individuals, the United States has seen a rise in diseases that were previously present at low levels. In 2008, the United States had 140 measles cases, more than any year since 1996, and as of May 20, 2011 the United States has documented 118 cases of measles, of which 89% were unvaccinated.[12] Additionally, there has been a rise in the number of pertussis cases throughout the United States, and Kansas has had several outbreaks in unvaccinated or undervaccinated populations in recent years.

**Limitations**

One limitation of this study is Hib3 and PCV3 are not required for school entry and may not consistently be reported on the immunization record, thus appearing to show decreased coverage levels for the individual vaccines. This is evident in Appendix 2 for several counties that have low levels for Hib3 and PCV3. Second, the sampling method employed excluded subjects with either a medical or religious exemption, which could have artificially increased coverage rates reported. However, the potential magnitude for the bias was small, as we estimated only approximately one percent of all students in kindergarten had an exemption on file, based on the records received. Third, no descriptive data are collected about sex, race, or ethnicity.

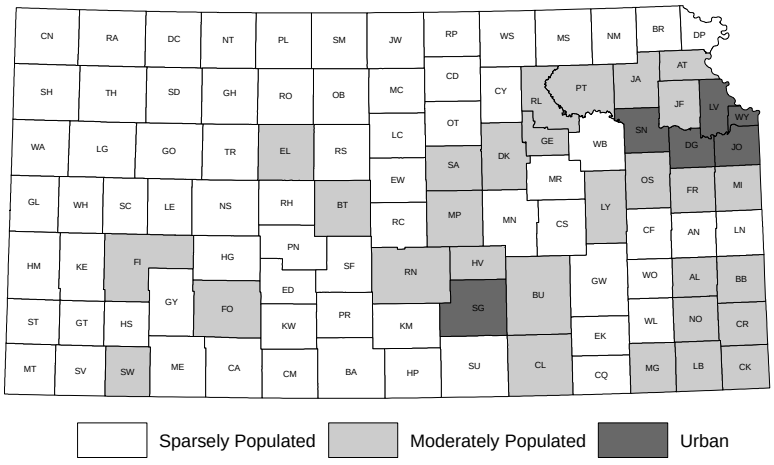
**Strengths**

Despite the limitations, the retrospective immunization survey provides a good estimation of early childhood immunization coverage levels for Kansas. It allows state and local officials to identify counties and regions with low vaccine coverage levels. Focus on these areas and implementation of enhanced vaccination delivery methods and educational campaigns can aid in Kansas achieving a 90% coverage goal. To aid in this goal, a similar survey is planned for next year.

[12] Centers for Disease Control and Prevention. Measles – United States, January – May 20, 2011. MMWR 2011; 60: 666-668.

**Appendix 1:** Kansas counties categorized based on population density, 2009.

| Sparsely Populated | | Moderately Populated | Urban |
|---|---|---|---|
| Anderson | Marshall | Allen | Douglas |
| Barber | Meade | Atchison | Johnson |
| Brown | Mitchell | Barton | Leavenworth |
| Chase | Morris | Bourbon | Sedgwick |
| Chautauqua | Morton | Butler | Shawnee |
| Cheyenne | Nemaha | Cherokee | Wyandotte |
| Clark | Ness | Cowley | |
| Clay | Norton | Crawford | |
| Cloud | Osborne | Dickinson | |
| Coffey | Ottawa | Ellis | |
| Comanche | Pawnee | Finney | |
| Decatur | Phillips | Ford | |
| Doniphan | Pratt | Franklin | |
| Edwards | Rawlins | Geary | |
| Elk | Republic | Harvey | |
| Ellsworth | Rice | Jackson | |
| Gove | Rooks | Jefferson | |
| Graham | Rush | Labette | |
| Grant | Russell | Lyon | |
| Gray | Scott | McPherson | |
| Greeley | Sheridan | Miami | |
| Greenwood | Sherman | Montgomery | |
| Hamilton | Smith | Neosho | |
| Harper | Stafford | Osage | |
| Haskell | Stanton | Pottawatomie | |
| Hodgeman | Stevens | Reno | |
| Jewell | Sumner | Riley | |
| Kearny | Thomas | Saline | |
| Kingman | Trego | Seward | |
| Kiowa | Wabaunsee | | |
| Lane | Wallace | | |
| Lincoln | Washington | | |
| Linn | Wichita | | |
| Logan | Wilson | | |
| Marion | Woodson | | |




Persons per Square Mile in Peer Groups
Sparsely Populated = ≤19.9
Moderately Populated = 20 – 149.9
Urban = ≥ 150.0

**APPENDIX 2:** Immunization Coverage Levels of Children 24 Months of Age for Kansas Counties 2010-2011 (percentages).*[§]

| COUNTY | DTaP4 | Polio3 | MMR1 | Hib3 | HepB3 | 4-3-1-3-3 | 4-3-1 | Var1 | PCV3 |
|---|---|---|---|---|---|---|---|---|---|
| *STATEWIDE* | *81* | *93* | *92* | *88* | *93* | *72* | *78* | *87* | *81* |
| ALLEN | 78 | 93 | 92 | 91 | 97 | 71 | 77 | 87 | 76 |
| ANDERSON | 83 | 96 | 91 | 95 | 98 | 81 | 81 | 85 | 89 |
| ATCHISON | 74 | 94 | 93 | 91 | 96 | 74 | 74 | 79 | 86 |
| BARBER | 74 | 100 | 93 | 96 | 100 | 74 | 74 | 89 | 85 |
| BARTON | 87 | 98 | 95 | 91 | 96 | 78 | 85 | 92 | 89 |
| BOURBON | 74 | 85 | 87 | 86 | 89 | 66 | 71 | 66 | 84 |
| BROWN | 77 | 94 | 92 | 88 | 94 | 69 | 76 | 72 | 79 |
| BUTLER | 76 | 91 | 88 | 89 | 92 | 71 | 73 | 84 | 83 |
| CHASE | 76 | 82 | 82 | 88 | 82 | 76 | 76 | 71 | 35 |
| CHAUTAUQUA | 88 | 100 | 96 | 96 | 96 | 85 | 88 | 88 | 85 |
| CHEROKEE | 75 | 91 | 92 | 86 | 93 | 72 | 75 | 89 | 89 |
| CHEYENNE | 75 | 96 | 83 | 92 | 92 | 67 | 71 | 88 | 92 |
| CLARK | 88 | 97 | 97 | 97 | 94 | 85 | 88 | 88 | 91 |
| CLAY | 86 | 93 | 90 | 90 | 95 | 85 | 85 | 90 | 90 |
| CLOUD | 80 | 92 | 91 | 89 | 94 | 72 | 78 | 89 | 87 |
| COFFEY | 83 | 93 | 92 | 91 | 93 | 76 | 78 | 89 | 84 |
| COMANCHE | 94 | 100 | 100 | 100 | 100 | 94 | 94 | 94 | 59 |
| COWLEY | 76 | 92 | 93 | 91 | 97 | 74 | 76 | 87 | 66 |
| CRAWFORD | 72 | 94 | 89 | 91 | 93 | 68 | 70 | 79 | 79 |
| DECATUR | 100 | 100 | 100 | 91 | 100 | 91 | 100 | 82 | 82 |
| DICKINSON | 84 | 91 | 91 | 93 | 90 | 75 | 80 | 89 | 90 |
| DONIPHAN | 83 | 91 | 91 | 89 | 95 | 80 | 83 | 80 | 83 |
| DOUGLAS | 79 | 90 | 92 | 81 | 92 | 66 | 75 | 87 | 74 |
| EDWARDS | 79 | 96 | 92 | 88 | 96 | 75 | 79 | 88 | 79 |
| ELK | 84 | 91 | 88 | 91 | 100 | 78 | 81 | 88 | 84 |
| ELLIS | 87 | 95 | 96 | 81 | 96 | 71 | 86 | 92 | 74 |
| ELLSWORTH | 88 | 91 | 91 | 91 | 93 | 86 | 86 | 90 | 91 |
| FINNEY | 83 | 96 | 92 | 95 | 96 | 82 | 83 | 90 | 92 |
| FORD | 87 | 96 | 97 | 92 | 98 | 83 | 86 | 92 | 74 |
| FRANKLIN | 71 | 93 | 89 | 87 | 93 | 66 | 69 | 87 | 87 |
| GEARY | 72 | 88 | 88 | 86 | 90 | 63 | 69 | 86 | 79 |
| GOVE | 74 | 96 | 93 | 93 | 96 | 74 | 74 | 89 | 78 |
| GRAHAM | 92 | 92 | 96 | 100 | 100 | 88 | 88 | 96 | 88 |
| GRANT | 83 | 97 | 95 | 93 | 96 | 81 | 83 | 93 | 82 |
| GRAY | 83 | 95 | 99 | 95 | 96 | 80 | 82 | 92 | 92 |
| GREELEY | 73 | 82 | 82 | 91 | 91 | 73 | 73 | 82 | 82 |
| GREENWOOD | 83 | 92 | 94 | 87 | 90 | 81 | 83 | 89 | 81 |
| HAMILTON | 96 | 100 | 96 | 100 | 100 | 96 | 96 | 96 | 92 |
| HARPER | 81 | 100 | 96 | 96 | 98 | 75 | 79 | 91 | 74 |
| HARVEY | 81 | 95 | 92 | 91 | 93 | 70 | 77 | 83 | 86 |
| HASKELL | 84 | 93 | 95 | 92 | 95 | 84 | 84 | 93 | 84 |
| HODGEMAN | 94 | 100 | 100 | 94 | 100 | 94 | 94 | 100 | 94 |
| JACKSON | 87 | 93 | 95 | 79 | 92 | 72 | 85 | 87 | 79 |
| JEFFERSON | 84 | 95 | 95 | 94 | 99 | 82 | 83 | 93 | 94 |

| COUNTY | DTaP4 | Polio3 | MMR1 | Hib3 | HepB3 | 4-3-1-3-3 | 4-3-1 | Var1 | PCV3 |
|---|---|---|---|---|---|---|---|---|---|
| *STATEWIDE* | *81* | *93* | *92* | *88* | *93* | *72* | *78* | *87* | *81* |
| JEWELL | 67 | 75 | 83 | 83 | 83 | 67 | 67 | 75 | 58 |
| JOHNSON | 84 | 94 | 92 | 85 | 92 | 69 | 81 | 90 | 80 |
| KEARNY | 82 | 90 | 92 | 90 | 94 | 80 | 82 | 94 | 90 |
| KINGMAN | 77 | 92 | 88 | 89 | 91 | 73 | 76 | 71 | 68 |
| KIOWA | 79 | 95 | 100 | 95 | 89 | 68 | 79 | 95 | 68 |
| LABETTE | 83 | 96 | 95 | 77 | 95 | 62 | 82 | 87 | 73 |
| LANE | 77 | 93 | 91 | 84 | 93 | 63 | 74 | 93 | 79 |
| LEAVENWORTH | 84 | 93 | 94 | 93 | 95 | 76 | 81 | 90 | 87 |
| LINCOLN | 81 | 93 | 96 | 89 | 93 | 78 | 81 | 96 | 96 |
| LINN | 76 | 93 | 92 | 91 | 93 | 68 | 73 | 77 | 85 |
| LOGAN | 91 | 100 | 100 | 91 | 97 | 82 | 91 | 94 | 97 |
| LYON | 86 | 94 | 94 | 92 | 94 | 81 | 85 | 82 | 43 |
| MARION | 83 | 95 | 90 | 88 | 88 | 71 | 81 | 82 | 80 |
| MARSHALL | 92 | 99 | 98 | 96 | 99 | 89 | 91 | 90 | 94 |
| MCPHERSON | 80 | 91 | 90 | 60 | 89 | 49 | 78 | 87 | 54 |
| MEADE | 83 | 97 | 97 | 93 | 97 | 83 | 83 | 93 | 91 |
| MIAMI | 70 | 88 | 88 | 87 | 91 | 65 | 68 | 85 | 86 |
| MITCHELL | 78 | 97 | 97 | 95 | 95 | 75 | 78 | 91 | 94 |
| MONTGOMERY | 78 | 92 | 90 | 89 | 93 | 68 | 74 | 89 | 85 |
| MORRIS | 84 | 94 | 89 | 89 | 91 | 78 | 83 | 88 | 59 |
| MORTON | 80 | 91 | 89 | 83 | 93 | 78 | 78 | 78 | 80 |
| NEMAHA | 91 | 96 | 95 | 95 | 98 | 86 | 88 | 85 | 83 |
| NEOSHO | 21 | 94 | 93 | 91 | 94 | 20 | 21 | 83 | 19 |
| NESS | 83 | 94 | 100 | 94 | 94 | 78 | 83 | 83 | 78 |
| NORTON | 92 | 100 | 97 | 100 | 98 | 88 | 90 | 90 | 62 |
| OSAGE | 90 | 94 | 95 | 94 | 95 | 86 | 88 | 91 | 90 |
| OSBORNE | 86 | 98 | 95 | 95 | 95 | 84 | 86 | 91 | 84 |
| OTTAWA | 89 | 92 | 97 | 97 | 97 | 86 | 86 | 92 | 97 |
| PAWNEE | 90 | 98 | 97 | 97 | 98 | 90 | 90 | 95 | 86 |
| PHILLIPS | 89 | 93 | 96 | 98 | 98 | 87 | 87 | 93 | 87 |
| POTTAWATOMIE | 90 | 99 | 96 | 92 | 92 | 79 | 88 | 90 | 91 |
| PRATT | 91 | 93 | 93 | 88 | 94 | 83 | 88 | 91 | 74 |
| RAWLINS | 83 | 100 | 100 | 100 | 100 | 83 | 83 | 92 | 100 |
| RENO | 93 | 96 | 93 | 96 | 98 | 86 | 89 | 88 | 93 |
| REPUBLIC | 88 | 96 | 94 | 94 | 98 | 82 | 84 | 86 | 90 |
| RICE | 69 | 86 | 91 | 82 | 87 | 65 | 68 | 81 | 71 |
| RILEY | 77 | 88 | 91 | 81 | 87 | 66 | 72 | 84 | 82 |
| ROOKS | 87 | 98 | 100 | 100 | 97 | 87 | 87 | 94 | 97 |
| RUSH | 93 | 96 | 93 | 96 | 100 | 86 | 89 | 96 | 93 |
| RUSSELL | 79 | 88 | 88 | 94 | 91 | 76 | 79 | 85 | 94 |
| SALINE | 85 | 94 | 94 | 92 | 97 | 81 | 82 | 90 | 94 |
| SCOTT | 89 | 95 | 93 | 95 | 98 | 89 | 89 | 89 | 95 |
| SEDGWICK | 80 | 91 | 91 | 91 | 93 | 72 | 75 | 88 | 85 |
| SEWARD | 76 | 93 | 91 | 92 | 97 | 73 | 74 | 86 | 85 |
| SHAWNEE | 82 | 92 | 91 | 89 | 93 | 75 | 80 | 89 | 86 |
| SHERIDAN | 88 | 100 | 100 | 100 | 100 | 88 | 88 | 100 | 100 |

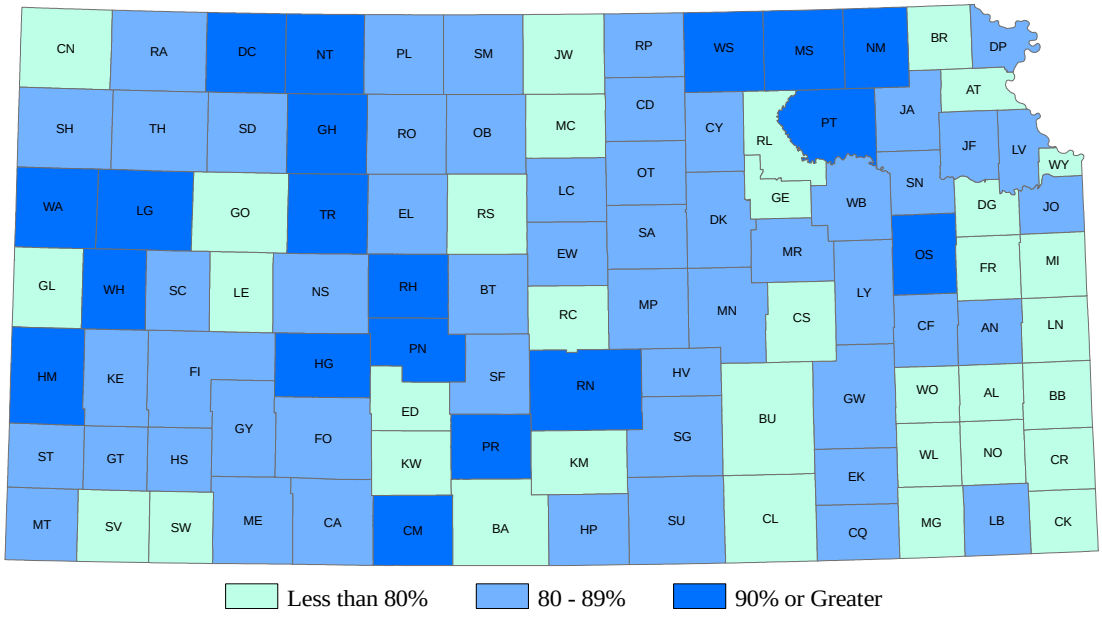
| COUNTY | DTaP4 | Polio3 | MMR1 | Hib3 | HepB3 | 4-3-1-3-3 | 4-3-1 | Var1 | PCV3 |
|---|---|---|---|---|---|---|---|---|---|
| *STATEWIDE* | *81* | *93* | *92* | *88* | *93* | *72* | *78* | *87* | *81* |
| SHERMAN | 87 | 96 | 100 | 96 | 100 | 85 | 87 | 91 | 94 |
| SMITH | 88 | 92 | 96 | 88 | 96 | 85 | 88 | 92 | 88 |
| STAFFORD | 88 | 98 | 96 | 90 | 98 | 85 | 88 | 88 | 77 |
| STANTON | 85 | 94 | 91 | 97 | 100 | 79 | 82 | 85 | 82 |
| STEVENS | 74 | 89 | 91 | 85 | 94 | 69 | 70 | 80 | 80 |
| SUMNER | 80 | 93 | 91 | 90 | 94 | 77 | 78 | 81 | 43 |
| THOMAS | 82 | 93 | 90 | 92 | 93 | 79 | 80 | 85 | 82 |
| TREGO | 96 | 100 | 96 | 89 | 100 | 85 | 93 | 96 | 89 |
| WABAUNSEE | 83 | 88 | 94 | 88 | 96 | 79 | 83 | 94 | 92 |
| WALLACE | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| WASHINGTON | 91 | 99 | 95 | 99 | 97 | 84 | 87 | 89 | 95 |
| WICHITA | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| WILSON | 69 | 90 | 86 | 88 | 93 | 66 | 68 | 87 | 83 |
| WOODSON | 67 | 85 | 82 | 79 | 85 | 61 | 67 | 70 | 70 |
| WYANDOTTE | 78 | 89 | 90 | 78 | 93 | 62 | 75 | 86 | 67 |

* Based on the retrospective survey for the school year starting 2010.

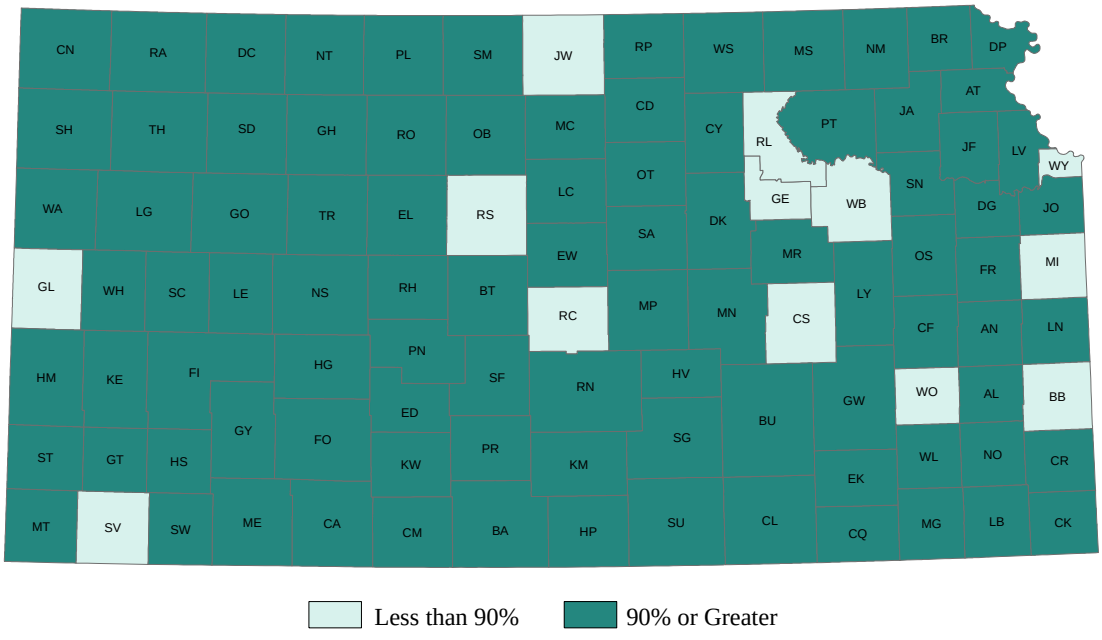
§ Due to Hib3 and PCV3 not being required for school entry, these vaccines may not consistently be reported on the immunization record, thus decreasing coverage levels for the individual vaccines, as well as the 4-3-1-3-3 series. This is evident for several counties that have low coverage levels for the 4-3-1-3-3 series as well as low Hib3 and PCV3 coverage levels.

**Appendix 3:** Maps of immunization coverage levels by county, 2010-11 Retrospective Survey.

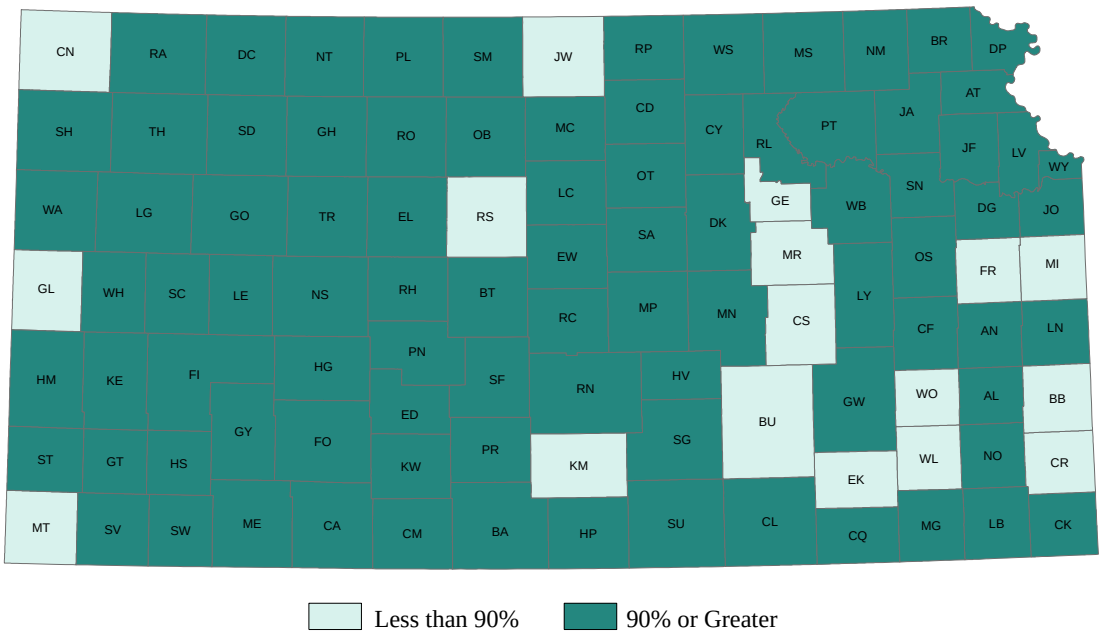
DTaP4 Coverage Levels for Retrospective Survey 2010-11



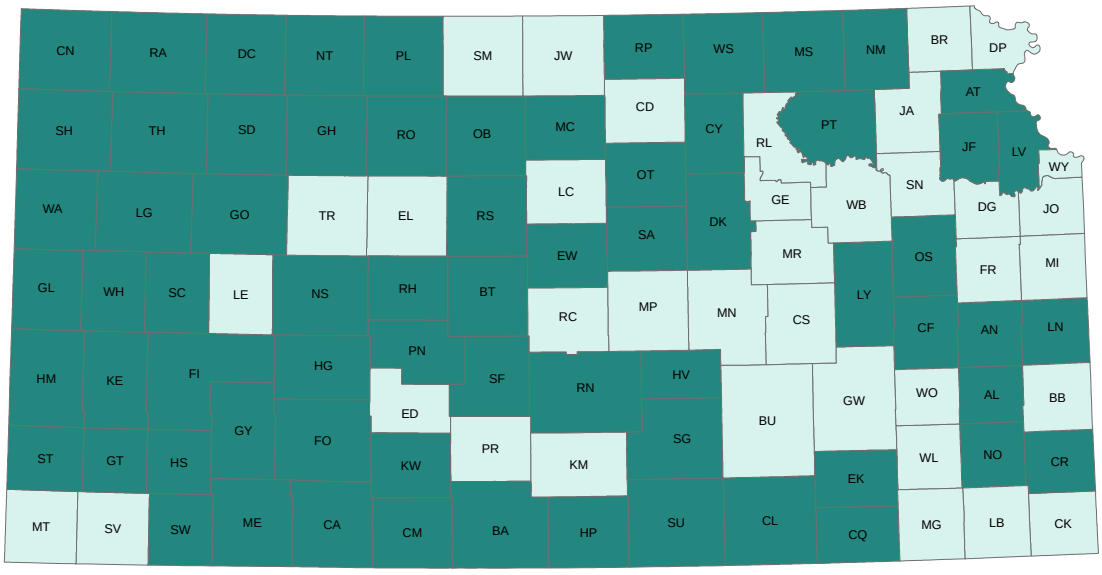

Polio3 Coverage Levels for Retrospective Survey 2010-11



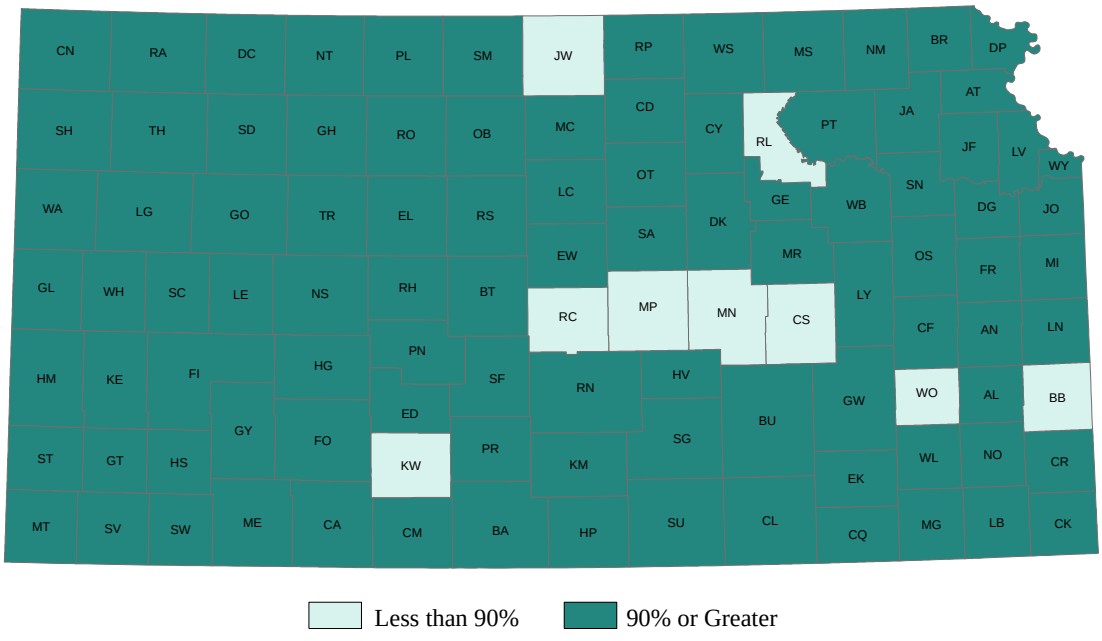
MMR1 Coverage Levels for Retrospective Survey 2010-11



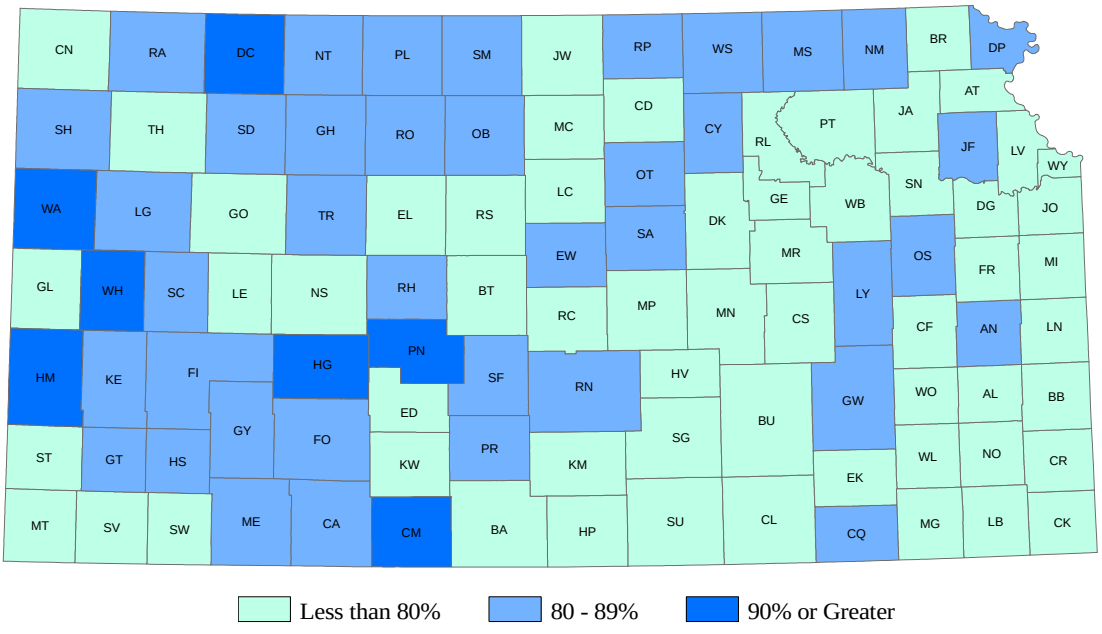

Hib3 Coverage Levels for Retrospective Survey 2010-11



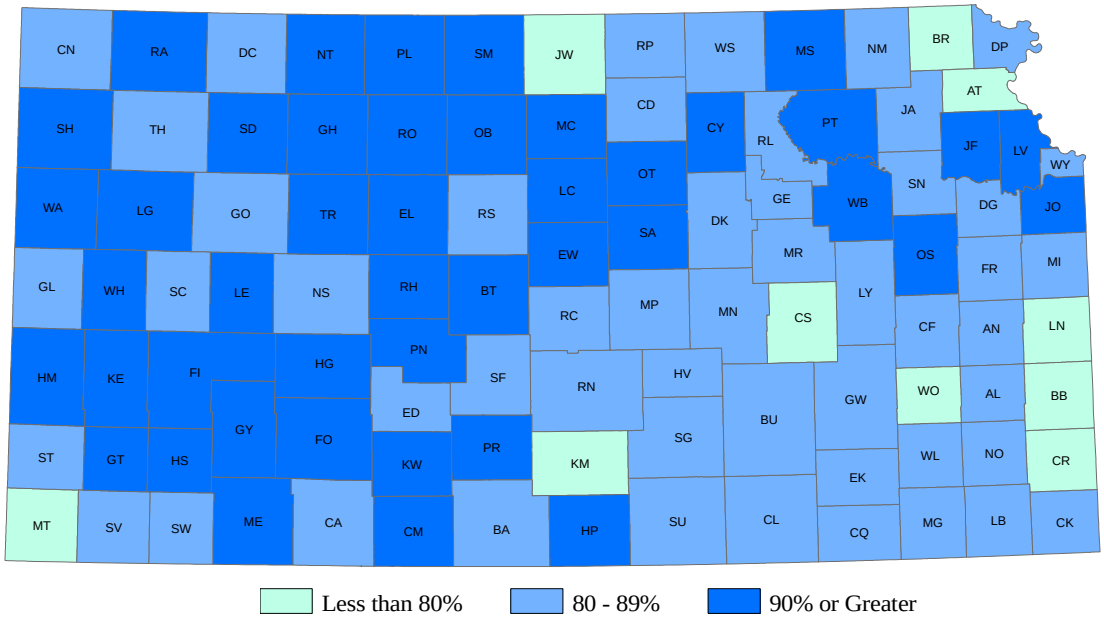
HepB3 Coverage Levels for Retrospective Survey 2010-11



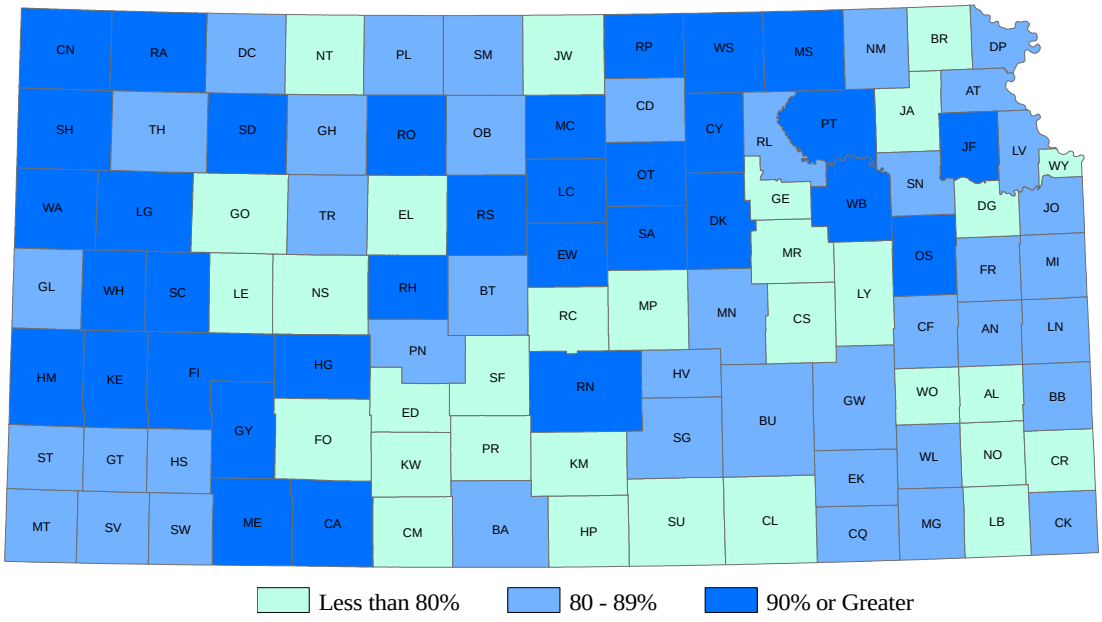

4-3-1-3-3 Series Coverage Levels for Retrospective Survey 2010-11



Var1 Coverage Levels for Retrospective Survey 2010-11

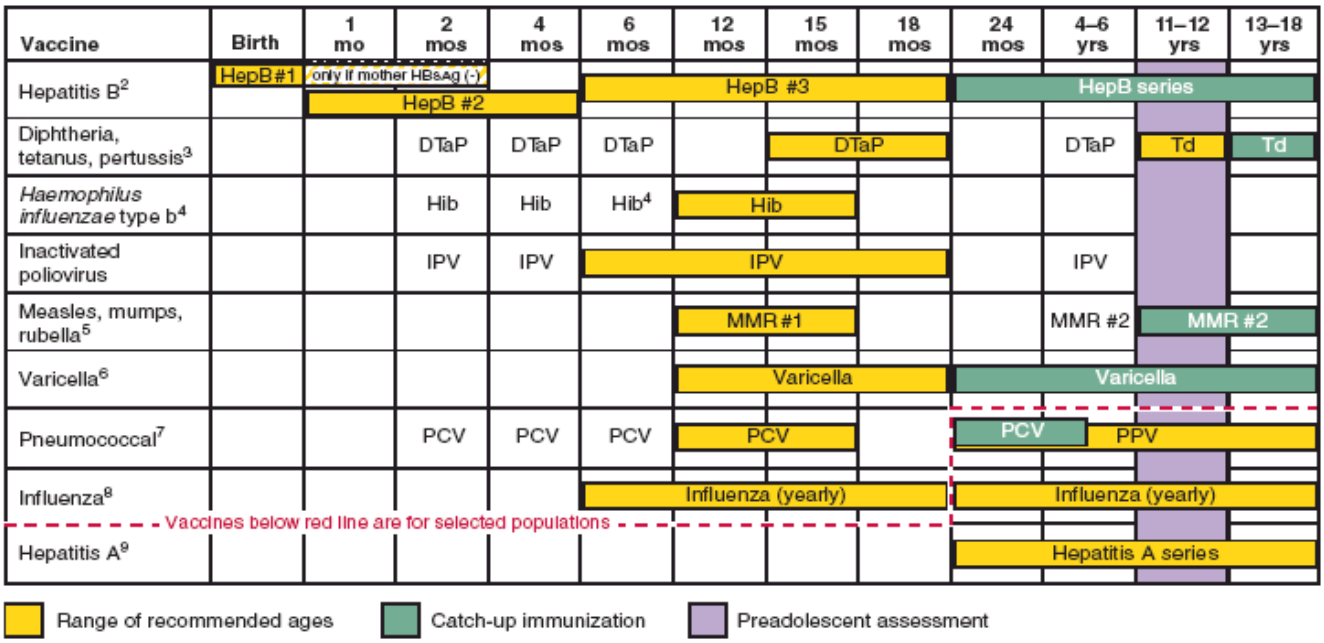



PCV3 Coverage Levels for Retrospective Survey 2010-11



## Appendix 4: CDC's 2005 Advisory Committee on Immunization Practices (ACIP) Recommendations http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5351-Immunizationa1.htm

**FIGURE. Recommended childhood and adolescent immunization schedule,[1] by vaccine and age — United States, 2005**




1. This schedule indicates the recommended ages for routine administration of currently licensed childhood vaccines, as of December 1, 2004, for children aged ≤18 years. Any dose not administered at the recommended age should be administered at any subsequent visit when indicated and feasible. ▭ Indicates age groups that warrant special effort to administer those vaccines not previously administered. Additional vaccines might be licensed and recommended during the year. Licensed combination vaccines may be used whenever any components of the combination are indicated and other components of the vaccine are not contraindicated. Providers should consult package inserts for detailed recommendations. Clinically significant adverse events that follow immunization should be reported to the Vaccine Adverse Event Reporting System; guidance is available at http://www.vaers.org or by telephone, 800-822-7967.

**2. Hepatitis B (HepB) vaccine.** All infants should receive the first dose of HepB vaccine soon after birth and before hospital discharge; the first dose may also be administered by age 2 months if the mother is hepatitis B surface antigen (HBsAg) negative. Only monovalent HepB may be used for the birth dose. Monovalent or combination vaccine containing HepB may be used to complete the series. Four doses of vaccine may be administered when a birth dose is administered. The second dose should be administered at least 4 weeks after the first dose, except for combination vaccines, which cannot be administered before age 6 weeks. The third dose should be administered at least 16 weeks after the first dose and at least 8 weeks after the second dose. The final dose in the vaccination series (third or fourth dose) should not be administered before age 24 weeks. ***Infants born to HBsAg-positive mothers*** should receive HepB and 0.5 mL of hepatitis B immune globulin (HBIG) at separate sites within 12 hours of birth. The second dose is recommended at age 1–2 months. The final dose in the immunization series should not be administered before age 24 weeks. These infants should be tested for HBsAg and antibody to HBsAg at age 9–15 months. ***Infants born to mothers whose HBsAg status is unknown*** should receive the first dose of the HepB series within 12 hours of birth. Maternal blood should be drawn as soon as possible to determine the mother's HBsAg status; if the HBsAg test is positive, the infant should receive HBIG as soon as possible (no later than age 1 week). The second dose is recommended at age 1–2 months. The last dose in the immunization series should not be administered before age 24 weeks.

**3. Diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine.** The fourth dose of DTaP may be administered as early as age 12 months, provided 6 months have elapsed since the third dose and the child is unlikely to return at age 15–18 months. The final dose in the series should be administered at age ≥4 years. **Tetanus and diphtheria toxoids (Td)** is recommended at age 11–12 years if at least 5 years have elapsed since the last dose of tetanus and diphtheria toxoid-containing vaccine. Subsequent routine Td boosters are recommended every 10 years.

**4. *Haemophilus influenzae* type b (Hib) conjugate vaccine.** Three Hib conjugate vaccines are licensed for infant use. If PRP-OMP (PedvaxHIB® or ComVax® [Merck]) is administered at ages 2 and 4 months, a dose at age 6 months is not required. DTaP/Hib combination products should not be used for primary immunization in infants at ages 2, 4, or 6 months but can be used as boosters after any Hib vaccine. The final dose in the series should be administered at age ≥12 months.

**5. Measles, mumps, and rubella (MMR) vaccine.** The second dose of MMR is recommended routinely at age 4–6 years but may be administered during any visit, provided at least 4 weeks have elapsed since the first dose and both doses are administered beginning at or after age 12 months. Those who have not previously received the second dose should complete the schedule by age 11–12 years.

**6. Varicella vaccine.** Varicella vaccine is recommended at any visit at or after age 12 months for susceptible children (i.e., those who lack a reliable history of chickenpox). Susceptible persons aged ≥13 years should receive 2 doses administered at least 4 weeks apart.

**7. Pneumococcal vaccine.** The heptavalent **pneumococcal conjugate vaccine (PCV)** is recommended for all children aged 2–23 months and for certain children aged 24–59 months. The final dose in the series should be administered at age ≥12 months. **Pneumococcal polysaccharide vaccine (PPV)** is recommended in addition to PCV for certain groups at high risk. See *MMWR* 2000;49(No. RR-9).

**8. Influenza vaccine.** Influenza vaccine is recommended annually for children aged ≥6 months with certain risk factors (including, but not limited to, asthma, cardiac disease, sickle cell disease, human immunodeficiency virus [HIV], and diabetes), health-care workers, and other persons (including household members) in close contact with persons in groups at high risk (see *MMWR* 2004;53[No. RR-6]). In addition, healthy children aged 6–23 months and close contacts of healthy children aged 0–23 months are recommended to receive influenza vaccine because children in this age group are at substantially increased risk for influenza-related hospitalizations. For healthy persons aged 5–49 years, the intranasally administered, live, attenuated influenza vaccine (LAIV) is an acceptable alternative to the intramuscular trivalent inactivated influenza vaccine (TIV). See *MMWR* 2004;53(No. RR-6). Children receiving TIV should be administered a dosage appropriate for their age (0.25 mL if aged 6–35 months or 0.5 mL if aged ≥3 years). Children aged ≤8 years who are receiving influenza vaccine for the first time should receive 2 doses (separated by at least 4 weeks for TIV and at least 6 weeks for LAIV).

**9. Hepatitis A vaccine.** Hepatitis A vaccine is recommended for children and adolescents in selected states and regions and for certain groups at high risk; consult your local public health authority. Children and adolescents in these states, regions, and groups who have not been immunized against hepatitis A can begin the hepatitis A immunization series during any visit. The 2 doses in the series should be administered at least 6 months apart. See *MMWR* 1999;48(No. RR-12).