RESULTS OF THE 2019 IMMUNIZATION STATUS SURVEY OF 24 MONTH OLD CHILDREN IN TENNESSEE

TN Department of Health

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Survey data were collected using REDCap electronic data capture tools hosted at the Tennessee Department of Health. REDCap (Research Electronic Data Capture, http://projectredcap.org/) is a secure web-based application designed to support data capture.

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Executive Summary

The Tennessee Department of Health (TDH) conducts an annual survey of the on-time immunization status of 24 month old children. The Tennessee Vaccine-Preventable Diseases and Immunization Program (VPDIP) uses these results to track progress toward achieving the national Healthy People 2020 (HP2020) objectives for immunization coverage with routinely recommended early childhood vaccines. HP2020 is a national framework established by the Federal Department of Health and Human Services (HHS) for meeting health goals by the year 2020. For best results, vaccines should be administered as recommended by the Advisory Committee on Immunization Practices (ACIP) and the Centers for Disease Control and Prevention (CDC).

Methods

The survey is composed of random, statistically-valid samples drawn from birth certificates of infants born during the first quarter of 2017 in each of Tennessee's six metropolitan counties and seven rural TDH regions. Local or state public health staff attempted to locate each child and confirm immunization histories with parents or guardians and healthcare providers. Statewide immunization rates are calculated, as well as rates for the six major metropolitan counties and seven rural multi-county regions. County rates within the rural regions are not calculated due to the small number of children sampled in each county. Complete on-time immunization in the 2019 survey of Tennessee 24 month olds is defined as having received four doses of diphtheria, pertussis, and tetanus (DTaP) vaccine, three doses of polio (IPV) vaccine, one dose of measles, mumps, rubella (MMR) vaccine, three *or* four doses of *Haemophilus* influenza type b (HIB) vaccine (depending on brand received) *or* any child clinically considered complete on the CDC's "catch-up" schedule, three doses of HBV vaccine, one dose of Varicella (Var) vaccine and four doses of pneumococcus (PCV) vaccine *or* any child considered complete for PCV based on the CDC's "catch-up" schedule. Combined these are known as the 4:3:1:FS:3:1:FS series. Additionally, this survey analyzes completion of hepatitis A (HAV), rotavirus (RTV), and seasonal influenza (Flu) vaccines.

Results

There were 1,573 children in the original survey sample and an additional 21 oversampled children for inclusion in the racial disparity analysis. After exclusion of 105 records (87 had moved out of state, two were sealed through adoption or placement in foster care, and one child had died) the final sample of 1,468 children was analyzed.

Of the 1,468 children analyzed, 76.6% were fully immunized for the 4:3:1:FS:3:1:FS vaccination series. There was no statistically significant difference in the series completion rates between black and white children; however, black children continue to be significantly under-immunized against influenza compared to their white peers (35.3% compared to 50.0%, respectively). Vaccine exemptions continue to increase; 4.2% (n=61) of parents claimed vaccine exemptions in 2019 with the majority of parents citing religious exemptions. At the end of the decade, Tennessee was able to meet only three of the 12 Healthy People 2020 objectives: PCV (91.9%), HBV (91.4%), and IPV (91.0%). In 2018, Tennessee met Healthy People 2020 objectives for five of the 12 antigens: IPV (92.3%), MMR (90.1%), HBV (92.7%), Var (90.3%), and HAV (90.8%). Because Healthy People 2020 evaluates two doses of HAV by 35 months of age and the 24 Month Old survey assesses one dose at age 24 months, comparison is no longer made between HAV and the HP2020 objective as of the 2019 report. The following table summarizes Tennessee's 2019 results alongside national Healthy People 2020 objectives:

Antigen	HP2020 objective (19-35 months)	Tennessee 2019 (24 months)
Diphtheria, Tetanus, Pertussis (DTaP)	90%	80.1%
Poliomyelitis (Polio)	90%	91.0%
Measles, Mumps, Rubella (MMR)	90%	88.3%
Hepatitis B (HBV)	90%	91.4%
Hepatitis B, birth dose	85%	81.4%
Haemophilus influenzae, type B (HIB)	90%	84.8%
Varicella (VAR)	90%	87.3%
Pneumococcus (PCV)	90%	91.9%
Full Series	80%	76.6%
Hepatitis A (HAV)*	N/A	*87.7%
Rotavirus (RTV)	80%	77.3%
Influenza (Flu)	70%	47.7%

Indicates value is above HP2020 objective.

*Hepatitis A is excluded from HP2020 objective comparisons as Tennessee measures receipt of one dose, while the HP2020 objective goal references two doses.

Comparison to National Rates

The National Immunization Survey-Child (NIS-Child) is an annual survey conducted by the CDC to assess ACIP recommended vaccination coverage of children 19-35 months. The 24 Month Old-Survey assesses coverage of the same ACIP vaccinations at 24 months of age. According to 2019 NIS-Child results, Tennessee children only met the HP2020 objective for polio with a coverage rate at 90.3%. Nationwide, children met four of the HP2020 objectives: IPV (92.7%), MMR (90.4%), HBV (91.0%), and Var (91.2%). According to the 2019 NIS-Child survey, Tennessee ranks in the bottom 20% of states for vaccine series completion of DTaP, HBV, birth dose HBV, HIB, PCV, MMR, and the 4:3:1:FS:3:1:4 series. Tennessee ranks in the bottom 40% of states for the remaining antigens: HAV, Flu, VAR, Polio, and RTV.[1]

Antigen	NIS-Child 2019	TN NIS-Child 2019	24-Month Old Survey
Diphtheria, Tetanus, Pertussis (DTaP)	80.3%	75.9%	80.1%
Poliomyelitis (Polio)	92.7%	90.3%	91.0%
Measles, Mumps, Rubella (MMR)	90.4%	87.1%	88.3%
Hepatitis B (HBV)	91.0%	88.2%	91.4%
Hepatitis B, birth dose	75.0%	69.9%	81.4%
Haemophilus influenzae, type B (HIB)	79.6%	71.2%	*84.8%
Varicella	91.2%	86.9%	87.3%
Pneumococcus (PCV)	81.0%	72.4 %	†91.9%
Full Series	68.5%	62.9%	76.6%
Hepatitis A (HAV)	84.7%	86.4 %	∫87.7%
Rotavirus (RTV)	73.6%	72.7%	77.3%
Influenza (Flu)	56.6%	53.4%	47.7%

* NIS-Child evaluates receipt of ≥2 or ≥3 doses, depending on product type received. 24 Month Old Survey accounts for brand and doses needed if first dose was after ACIP-recommended age, but before 24 months

† NIS-Child evaluates receipt of ≥4 doses. 24-Month Old survey accounts for doses needed if 1st dose was after ACIP recommendation but before 24 months of age

∫ Both NIS-Child and 24-Month Old Survey results reported are for one dose of HAV as of 24 months of age

Racial Disparity

Influenza vaccination rates continue to be significantly lower among black children compared to white children. In 2019, 35.3% of black children received at least two doses of influenza vaccine compared to 50.0% of white children. Although completion of the full childhood series (4:3:1:FS:3:1:FS) has been consistently lower for black children than white children, the difference is not statistically significant. The 2019 series completion rate among blacks and whites was 73.3 and 77.3%, respectively.

Influenza Vaccination

Children six months through eight years of age require two doses of the influenza vaccine in their first season; thus, they should have received three doses prior to the second birthday. The percentage of infants receiving two and three doses of influenza vaccine in Tennessee has been variable. In 2018, two dose coverage increased from 45.9% to 49.0% and three dose coverage increased from 25.6% to 27.0%. However, in 2019, two dose coverage decreased from 49.0% to 47.4%, and three dose coverage decreased from 27.0% to 26.0%.

Trends in Vaccination Refusals

Over the past 5 years, percentage of children included in the survey whose parents refused some or all immunizations has ranged from 1.6% to 3.5%. This 2019 survey marks the first year in the history of the survey where vaccine refusals have risen above 4%, with 4.2% (61/1468) of parents refusing some or all immunizations. The number of medical refusals in Tennessee has remained low over the past five years (< 1%), while religious and philosophical refusals have continued to rise. In 2019, 2.2% (n=33) of refusals were religious and 1.7% (n=25) were philosophical refusals.

Discussion

While overall vaccination rates among children in Tennessee remain relatively high, the reintroduction of previously eliminated vaccine-preventable diseases across the United States emphasizes the importance of continued vigilance in ensuring that every medically-eligible child is fully vaccinated on-time and according to the ACIP and CDC recommended childhood vaccination schedule. Tennessee currently meets HP2020 targets for only three of 12 measures in 24 month old children and ranks among the bottom 20% of states for completion of six of the 12 vaccines assessed, as well as the 4:3:1:FS:3:1:FS series. Furthermore, the increasing percentage of parents who are refusing immunizations is placing all Tennesseans at greater risk for significant morbidity and mortality from vaccine-preventable diseases.

Definitions of Abbreviations in Charts

1. Vaccines

a. DTaP: diphtheria, tetanus, acellular pertussis vaccine
b. IPV: inactivated polio vaccine
c. HAV: hepatitis A vaccine
d. HBV: hepatitis B vaccine
e. HIB: *Haemophilus influenzae,* type B vaccine
f. MMR: measles, mumps, rubella vaccine
g. VAR: varicella (chickenpox) vaccine
h. PCV: pneumococcal conjugate vaccine
i. FLU: seasonal influenza vaccine
j. RTV: rotavirus vaccine

2. Public Health Regions

a. Rural, multi-county regions
    i. NER: Northeast Region
    ii. ETR: East Tennessee Region
    iii. SER: Southeast Region
    iv. UCR: Upper Cumberland Region
    v. SCR: South Central Region
    vi. MCR: Mid-Cumberland Region
    vii. WTR: West Tennessee Region
b. Metropolitan, single county regions
    i. SUL: Sullivan County Region
    ii. KKR: Knoxville-Knox County Region
    iii. CHR: Chattanooga-Hamilton County Region
    iv. NDR: Nashville-Davidson County Region
    v. JMR: Jackson-Madison County Region
    vi. MSR: Memphis-Shelby County Region

Introduction

An annual Survey of the Immunization Status of 24 Month Old Children is conducted by the Tennessee Department of Health's (TDH) Vaccine-Preventable Diseases and Immunization Program (VPDIP) to track progress toward achieving at least 90% on-time immunization with each routinely recommended vaccine for that population. The survey is composed of random, statistically-valid samples drawn from birth certificates of infants born in each of the 13 health department regions, which are aggregated to give statewide statistics on immunization coverage rates in Tennessee.

Safety and Efficacy of Immunizations

The United States has the safest and most effective vaccine supply in its history. Prior to licensure, rigorous clinical trials are carried out by the vaccine manufacturers and reviewed by the Food and Drug Administration (FDA). Vaccines are recommended only when proven to be safe, effective, and beneficial. After licensure, vaccines continue to be monitored for rare adverse reactions. The majority of vaccinated children never experience an adverse reaction to a vaccine. The most frequently reported adverse reactions are minor and include soreness at injection site, a rash, or a mild fever that subsides within a day or two[2].

Vaccines help the body build immunity against disease. Because of the success of vaccines, many diseases that were historically common place have become rare or have been eliminated from the United States. By vaccinating a child, benefits also extend to others. Individuals who cannot develop immunity from vaccines, have medical conditions that do not allow them to be vaccinated, and babies who are too young to be vaccinated rely on the immunity of those around them to protect them from serious infectious diseases.[3]

Value of Immunizations

Timely routine vaccination of children protects health, saves money, and saves lives. The federal Vaccines for Children (VFC) Program, implemented in 1994, assures affordable access to all routine vaccines for children who are without private insurance coverage. In Tennessee, over 600 providers across the state are administering VFC vaccines and there is at least one VFC provider in each of Tennessee's 95 counties. The CDC has reported that the routine vaccines already given to U.S. children born between 1994 and 2013 will prevent an average of 4.1 illnesses per child, prevent the hospitalization of one in four and prevent the premature death of nearly one in 100 of these children over their lifetimes.[4] The CDC calculates that vaccination of each U.S. birth cohort according to the current immunization schedule yields a net savings of nearly $14 billion in direct medical costs and $69 billion in total costs to society.[5] With roughly two percent of the U.S. population living in Tennessee, this suggests Tennessee has benefitted from the prevention of approximately 480,000 cases of disease in the past decade, with ***annual savings*** **of $280 million in direct medical costs and $1.38 billion in total costs to society.**

In Tennessee specifically, unvaccinated and under-vaccinated children have comprised substantial proportions of cases of vaccine-preventable diseases such as measles, mumps, and pertussis (whooping cough), and the majority of children who die each year from seasonal influenza are unvaccinated.[6,7] These diseases not only place Tennesseans at risk for significant morbidity and mortality, but also create significant fiscal burden upon the State. A 2016 outbreak of seven cases of measles in west Tennessee, for example, resulted in an estimated cost of more than $4 million. Even small outbreaks place tremendous strain upon our public health system and its resources and divert attention from other critical public health initiatives.

Vaccines Assessed

This survey assesses vaccine completion according to the Advisory Committee on Immunization Practices' (ACIP) recommendations for protection against ten serious illnesses before the age of 24 months: diphtheria, tetanus, pertussis (combined as DTaP), poliomyelitis (IPV), measles, mumps, rubella (combined as MMR), *Haemophilus* influenza type B (HIB), hepatitis B (HBV), varicella (Var), and pneumococcus (PCV). Combined, these are known as

the 4:3:1:FS:3:1:FS series[8]. Additionally, this survey analyzes completion of hepatitis A (HAV), rotavirus (RTV), and seasonal influenza (Flu) vaccines.

Table 1. ACIP List of Diseases to Prevent through Vaccination of Children < 24 Months of Age

Disease(s)	Possible complications of disease
Diphtheria, Tetanus, Pertussis	*Diphtheria*: upper airway obstruction, pneumonia, respiratory failure, death
	Tetanus: spasms of respiratory and skeletal muscles, death
	Pertussis: outbreaks; severe, long-term cough, vomiting, breathlessness, death in infants
Poliomyelitis	Paralysis, death
Measles, Mumps, Rubella	*Measles:* outbreaks; ear infections, pneumonia, cardiac and neurologic problems, encephalitis, death
	Mumps: outbreaks; decreased fertility, meningitis, arthritis, hearing impairment
	Rubella: arthritis, encephalitis, birth defects
***Haemophilus influenzae* type B**	Pneumonia, meningitis, neurologic problems, death
Hepatitis B	Fulminant hepatitis, jaundice, liver cancer, cirrhosis, premature death
Varicella (chickenpox)	Rash illness, severe disease in immunocompromised, birth defects, encephalitis, death
Pneumococcus (certain strains)	Ear infections, pneumonia, meningitis, blood stream infections, death
Hepatitis A	Outbreaks: fever, nausea, jaundice, death
Influenza	Outbreaks: secondary pneumonia, exacerbation of chronic diseases, hospitalizations, death
Rotavirus	Outbreaks in daycare settings, dehydration, hospitalization, death

Special Vaccine Considerations

Hepatitis A vaccine (HAV)

HAV is a two-dose series, starting on or after the first birthday. As the recommended dose spacing is 6-18 months, children who have only one dose by the second birthday are still on schedule. For this reason, this survey reports 24 Month Old children as up-to-date with one dose of HAV. HAV will not be compared to HP2020 objectives in this report, as the HP2020 objective reflects completion of the 2-dose series.

Hepatitis B vaccine (HBV) birth dose

In 2016, the CDC revised its guidance to recommend routine administration of a hepatitis B birth dose within 24 hours of life (rather than prior to discharge). A birth dose of hepatitis B vaccine is defined in the 24 Month Old survey as a dose given within the first three days of life. Birth dose hepatitis B is a key strategy to eliminate transmission of the hepatitis B virus from an infected mother to her infant.

Influenza vaccine (FLU)

Influenza vaccine (FLU) is given annually to children aged six months and older; two doses should be given during a child's first influenza season. Because protection is conferred only after two doses, this survey measures the proportion of children who have received two or more doses by their second birthday.

Haemophilus influenzae type B vaccine (HIB)

Two HIB schedules exist, depending upon the vaccine used. The full series (FS) of the Merck product requires three doses; the FS of the Sanofi Pasteur product requires four doses. Any mixed-brand schedule requires four doses.

Any child receiving one or more doses of the 4-dose HIB product must have received four doses before the 25th month of life in order to be considered complete and on-time. This classification by HIB products administered reduces the degree of overestimation of on-time completion demonstrated by past reports.

Rotavirus vaccine (RTV)

Similarly to HIB vaccine, two rotavirus vaccine products are available with different dosing schedules. Rotateq© (Merck), requires three doses; Rotarix© (GSK) requires two doses. Mixed brand schedules require three doses. RTV is unique among vaccines as the series must be initiated no later than 15 weeks of age and no doses should be given after eight months of age.

Healthy People 2020 objectives

Healthy People 2020 (HP2020) objectives are established by the federal Department of Health and Human Services (HHS) to provide national targets for population health. These objectives include vaccine coverage levels among children 19-35 months of age and are tracked nationally through the National Immunization Survey (NIS). TDH aims to reach or exceed each of these targets.

The following objectives for the percentage of children immunized between 19-35 months of age have been established by HP2020 and are relevant comparisons to the results of this survey:

- 80% complete the 4:3:1:FS:3:1:FS series
- 90% complete each individual vaccine included in the 4:3:1:FS:3:1:FS series
- 80% complete rotavirus vaccination with two or more doses
- 70% complete influenza vaccination with two or more doses
- 85% of all children receive their first dose of hepatitis B vaccine within three days of life

Methods

In each of the 13 public health jurisdictions in Tennessee, 121 children born in the first three months of 2017 were sampled. Oversampling for black children was done in each region where the random sample contained fewer black children than the actual proportion of black children born in the first quarter of 2017 in that region.

Vaccine information made available through the Tennessee Immunization Information System (TennIIS) for all sampled children is provided to local or state public health staff. These staff then attempt to locate each child and confirm immunization histories with parents or guardians and healthcare providers. All information is tracked in a secure, online database system, REDCap.

Vaccine Completion Logic

Complete on-time immunization in this survey is defined as having received four doses of DTaP vaccine, three doses of IPV vaccine, one dose of MMR vaccine, three *or* four doses of HIB vaccine (depending on brand received *or* any child clinically considered complete on a "catch-up" schedule), three doses of HBV vaccine, one dose of VAR vaccine and four doses of PCV vaccine (*or* any child considered complete for PCV based on the CDC's "catch-up" schedule).

Prior to 2014, *Haemophilus influenzae* type B (HIB) and rotavirus (RTV) vaccination were counted as complete with three doses or two doses, respectively, as brand information was unavailable. Beginning in 2014, a change in methodology was introduced to provide a more accurate assessment of HIB vaccination and RTV vaccination rates, as different formulations of vaccines require different numbers of doses. This survey now takes into account the vaccine brand, if known, and classifies a child as complete only if the appropriate number of doses has been administered. If any documented HIB dose was given as the 4-dose product, then only receipt of four doses was considered as a complete series. In the absence of documentation of vaccination brand, receipt of four doses of HIB is classified as series completion. Likewise, if any documented RTV dose was given as the 3-dose product, then only receipt of three doses was considered as a complete series. In the absence of documentation of vaccination brand, three doses of RTV is classified as a complete series. As a result, point estimates for HIB and RTV coverage rates are lower than previous estimates, but also more accurate and more consistent with methods used by the CDC.

In 2019, additional analysis was included to account for the HIB and PCV catch-up schedules. Prior to 2019, counts of vaccinations were used to calculate series completion for both HIB and PCV; however, this inaccurately captured completion for these vaccines due to the unique vaccination schedules that exist when a child receives their first dose after the recommended age, but prior to 24 months. By assessing completion based off of dosing needs from the first vaccination event, HIB and PCV completeness more accurately mirrors ACIP forecasting and clinical decision-making.

Table 2. Catch-Up Guidance for PCV and HIB, Centers for Disease Control and Prevention[9]

Age at Dose 1	Age at Dose 2	Age at Dose 3	**Recommendation**
PCV			
< 12 months old	< 12 months old	< 12 months old	**Needs 4th dose 8 weeks later**
< 12 months old	Between 7-11 months old		**Needs 3rd dose 8 weeks later**
> 12 months old			**Needs 2nd dose 8 weeks later**
24-25 months			**No additional dose needed**
HIB			
< 12 months old	< 12 months old	< 12 months old	**Needs 4th dose 8 weeks later**
< 12 months old	Between 12-14 months old		**Needs 3rd dose 8 weeks later**
< 12 months old	> 15 months old		**No additional dose needed**
Between 12-14 months			**Needs 2nd dose 8 weeks later**
> 15 months old			**No additional dose needed**

Program Enrollment

The survey captures the immunizing provider type (public, private or both), TennCare (Medicaid) participation, and enrollment in the Women, Infants and Children (WIC) nutrition program for each child. Children are counted

under TennCare or WIC if they were ever enrolled in these programs. Infants in WIC have immunization records reviewed at WIC visits. Targeted education and telephone follow-up are the primary tools used to encourage catch-up immunization of WIC infants.

Statistical Notes

The survey is designed to allow valid statistical comparisons of the populations in each of the 13 health department regions; however, the sample size within multi-county regions is too small for meaningful results at the county level or useful comparisons among subpopulations within a region.

Ninety-five percent confidence intervals (CI) were calculated and are displayed as grey bands on the graphs in this report to permit readers to visualize the statistical significance (or absence of significance) of differences in point estimates. Confidence intervals that do not overlap indicate that the point-estimates being compared have at least a 95% chance of representing true differences in the populations being compared (statistically significantly different). When CIs overlap, differences are not considered to be statistically significant.

Sampling Comparison Limitation

For the seven multi-county TDH regions (Northeast [NER], East Tennessee [ETR], Southeast [SER], Upper Cumberland [UCR], South Central [SCR], Mid-Cumberland [MCR], West Tennessee [WTR]) in this survey, children were chosen in different proportions from the counties that make up each region. There is no consistent pattern for choosing these participants from year to year. Results are presented as the summation of all counties in that region; therefore, use of the results of this survey for county-level estimates is not appropriate.

Results

The 2019 Sample Population

In 2019, the statewide sample consisted of 1,573 children and an additional 21 black children for inclusion in the racial disparity analysis. Children who moved out of the state, for whom the birth record was sealed (e.g. through adoption or placement in foster care), for whom the parents or guardians refused to participate in the survey, and children who had died were excluded from the survey. Of the 1,573 sampled births, 105 records were excluded from the final analysis: one child had died; parents of 15 refused to participate; 87 had moved out of state; and two had been adopted, put in foster care or were in state's custody. None of the 21 oversampled children were excluded from the racial disparity analysis. The point estimates reported in this survey were based off of the 1,468 analyzed sample population; the 1,573 sampled births minus the 105 excluded records. When reporting on racial analysis, the oversampled population is included in the denominator. Due to small sample size, children of other races (n=29 or 2% of children sampled) were not included in analysis. The final number of children included in the racial analysis sample was 1,460 (1,468 + 21 oversampled records – 29 other races = 1,460 total records).

The children sampled were 81.3% white, 16.7% black, and 2% other races. 8.4% (125) considered themselves Hispanic/Latino. This survey does not differentiate between Hispanic whites and non-Hispanic whites; for that reason, racial disparity based upon Hispanic ethnicity was not analyzed. The majority (81.9%) of children received all of their vaccinations at a private provider office, while 14.4% received vaccinations from both a health department and a private provider, and 3.7% of children received vaccinations at a health department alone. 64.6% of children had been enrolled in TennCare, 56.5% had been enrolled in WIC, and 52.2% had been enrolled in both TennCare and WIC.

Nearly one-third (29.6%) of all mothers of sampled children had a high-school diploma, 14.8% had less than a high-school diploma, and 55.6% had more than a high-school diploma. The father's education level was unknown for 16%, 12% had less than a high-school diploma, 30% had a high-school diploma, and 42% had more than a

high-school diploma. Of the 1,468 children, 573 (39%) had no siblings, 493 (33.6%) had one sibling, and 402 (27.4%) had two or more siblings; the number of siblings is known to impact completion of vaccines.

Table 3. Demographics of 2019 sample population, excluding oversampled black children (n=1468)

Race			**Vaccination Source**		
	N	**%**		**N**	**%**
Black	245	16.7	Private Provider	1138	81.9
White	1194	81.3	Health Department	51	3.7
Other	29	2.0	Both	200	14.4
Hispanic*	125	8.4			
Siblings			**Program Enrollment**		
	N	**%**		**N**	**%**
0	573	39.0	WIC	830	56.5
1	493	33.6	TennCare	949	64.6
2+	402	27.4	Both	766	52.2
Maternal Education			**Paternal Education**		
	N	**%**		**N**	**%**
< High School Diploma/ GED	214	14.8	< High School Diploma/ GED	408	28.0
High School Diploma/ GED	437	29.6	High School Diploma/ GED	444	30.0
> High School Diploma/ GED	817	55.6	> High School Diploma/ GED	616	42.0

*This survey does not distinguish between Hispanic whites and non-Hispanic whites.

Non-Compliance

Vaccine Refusals

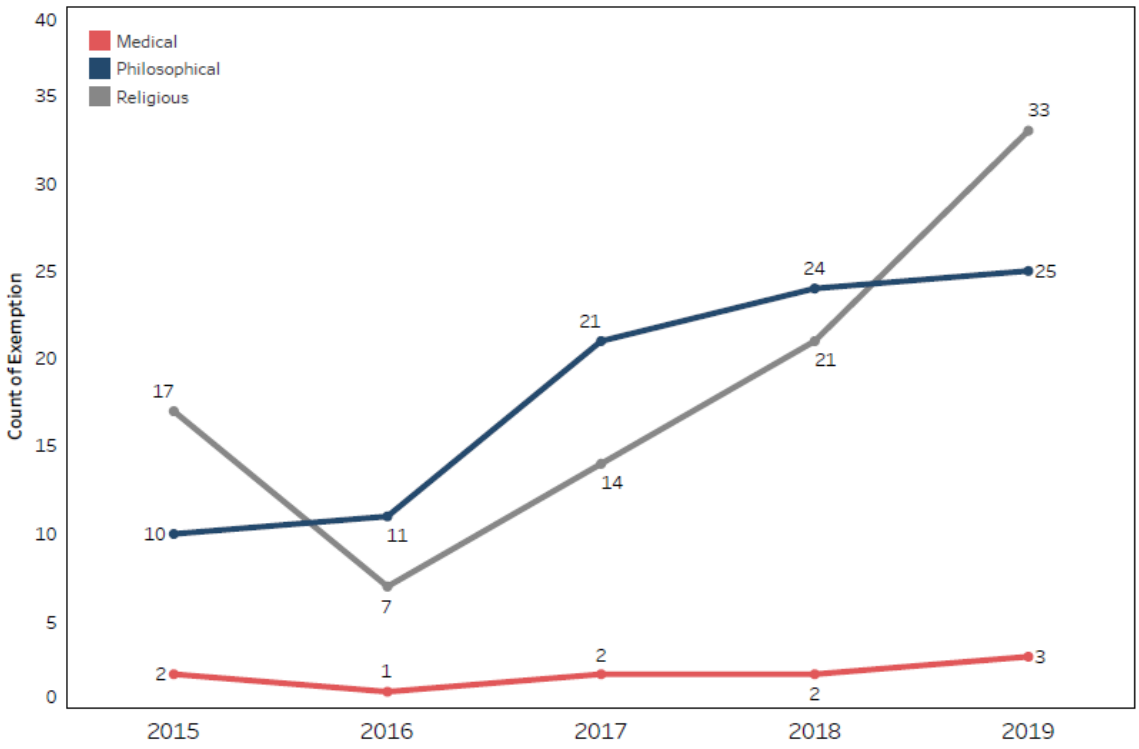
There were 61 (4.2%) documented vaccine refusals reported in 2019; this is the highest number of vaccine refusals reported since this survey's inception. Thirty-three claimed religious exemption, twenty-five claimed philosophical objection, and three claimed a medical exemption. Regionally, vaccine-refusals ranged from 1.7% to 11.3% of the sampled populations. Nine of the 61 children whose parents refused vaccines were partially immunized (ranging from 3-26 total doses). Parents of six of the nine partially immunized children cited philosophical reasons and three cited medical reasons for refusal of vaccines.

There has been an annual incremental increase in parents refusing immunizations. While medical refusals have remained consistent over the past five years (≤ 5% of refusals year), refusals for philosophical and religious reasons have increased, with religious exemptions increasing at a higher rate than philosophical exemptions. In 2015, parents of 10 (0.7%) children claimed religious exemption compared to 25 (1.7%) in 2019, and parents of 17 (1.1%) children claimed philosophical exemption compared to 33 (2.2%) in 2019.

Table 4. Vaccine Refusal Reasons by Region, Tennessee, 2019 (n=1468)

Region	N	Religious	%	Philosophical	%	Medical	%	Total	%
NER	118	0	0	2	1.7	0	0	2	1.7
ETR	114	5	4.4	5	4.4	0	0	10	8.8
SER	111	2	1.8	3	2.7	2	1.8	7	6.3
UCR	110	3	2.7	1	0.9	0	0	4	3.6
MCR	112	0	0	3	2.8	0	0	3	2.8
SCR	115	10	8.7	3	2.6	0	0	13	11.3
WTR	112	3	2.7	1	0.9	0	0	4	3.6
MSR	114	1	0.9	0	0	0	0	1	0.9
NDR	113	0	0	2	1.8	1	0.9	3	2.7
KKR	107	2	1.9	0	0	0	0	2	1.9
CHR	115	4	3.5	2	1.7	0	0	6	5.2
JMR	114	2	1.8	2	1.8	0	0	4	3.6
SUL	113	1	0.9	1	0.9	0	0	2	1.8
STATE	1468	33	2.2	25	1.7	3	0.2	61	4.2

Figure 1. Five-Year Trend of refusals by reason, Tennessee, 2019.



Unable to Locate

Of the 1,468 children included in the survey, 57 had incomplete information in the Tennessee Immunization Information System (TennIIS) and could neither be located nor confirmed as having moved out of state. 6.1% (4/228) of black children and 5.7% (3/27) of other races were unable to be located, compared to 3.7% (40/1078) of white children. 22 of the 57 who were unable to be located were in Nashville Davidson Region, accounting for 19.5% of the county's survey sample and 38.5% of all of those unable to be located. (See Table 5 for the breakdown of those unable to be located by region.)

TDH uses Accurint, a subscription-based database compiling publicly available address information, to generate contact details for parents of each child. These were provided to local and regional health department staff at the beginning of the survey period.

Table 5. Unable to Locate (UTL) by Region, Tennessee, 2019

Region	NER	ETR	SER	UCR	MCR	SCR	WTR	MSR	NDR	KKR	CHR	JMR	SUL	STATE
Number sampled	118	114	111	110	112	115	112	114	113	107	115	114	113	1468
UTL	0	2	0	0	6	13	0	9	22	1	1	0	3	57
%	0	1.8	0	0	5.4	11.3	0	7.9	19.5	0.9	0.9	0	2.7	3.9

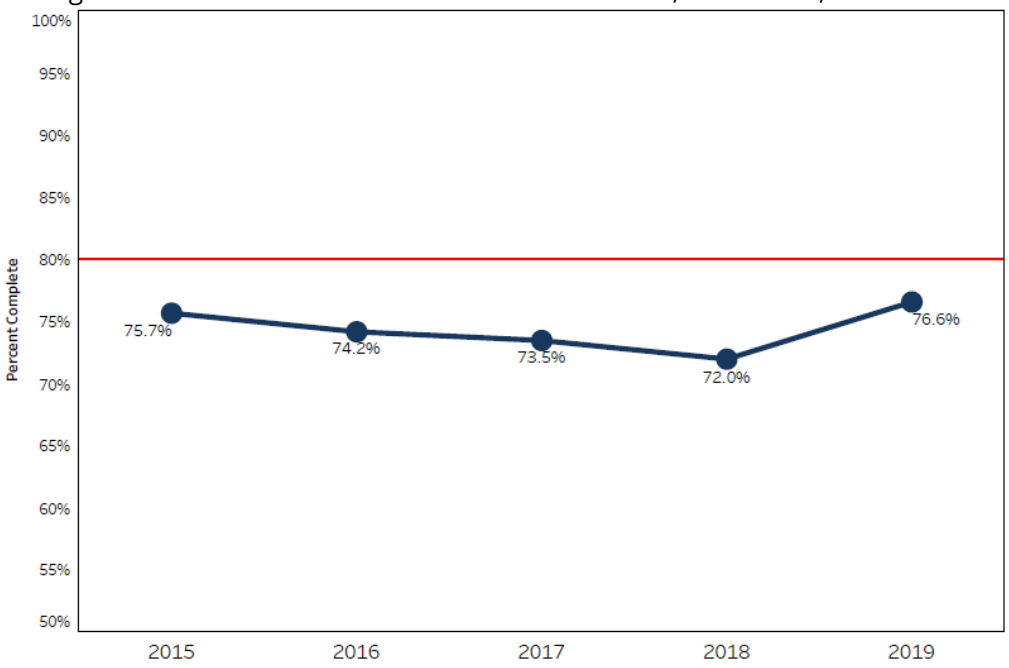
Statewide Results

Complete 4:3:1:FS:3:1:FS series rates from 2015-2019 are shown in Figure 2. While coverage has fluctuated slightly over the years, no statistically significant changes have been observed. 4:3:1:FS:3:1:FS series rates in 2019 included catch-up HIB and catch-up PCV completion for those who received first dose after the ACIP recommended age but before 24 months.

The overall statewide coverage estimate for the full, recommended 4:3:1:FS:3:1:FS series was 76.6% (95% CI: 74.4-78.7) and is shown in Figure 3. The light blue bars represent the individual antigens that make up the 4:3:1:FS:3:1:FS series, the navy bar is the 4:3:1:FS:3:1:FS, and the dark grey bars represent the additional antigens assessed in the survey. The red lines represent HP2020 objectives for each antigen assessed, and the lighter grey bands represent the 95% Confidence Intervals (CI).

Figure 4 shows the statewide and regional percentages of children immunized on-time with all vaccines in the 4:3:1:FS:3:1:FS series. Among the lowest completed vaccinations are DTaP and HIB, both of which require a final dose after 12 months of age. Influenza vaccination rates remain low with 47.4% of children having received at least two doses. The first dose of HAV vaccine was received by 87.7% (95% CI: 86.0-89.3) of children by 24 months of age.

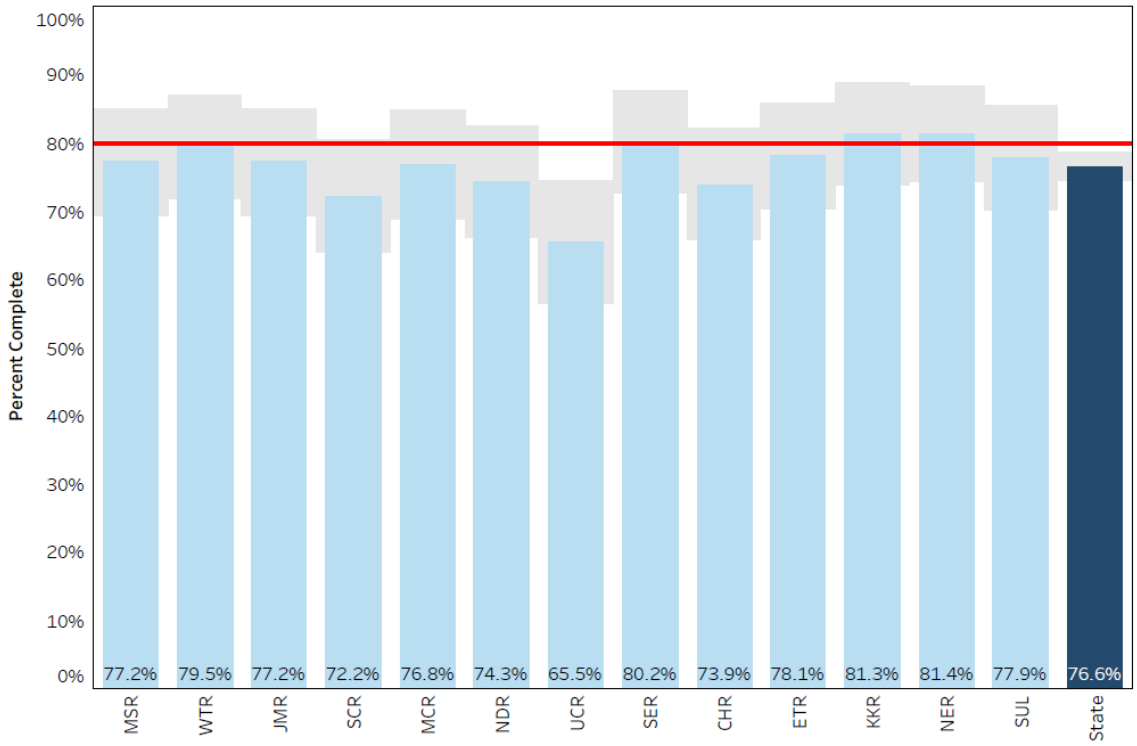
Figure 2. 4:3:1:FS:3:1:FS Immunization Rate Trends, Tennessee, 2015- 2019



Full Series

The statewide and regional percentages of children immunized on-time with all vaccines in the 4:3:1:FS:3:1:FS series are shown in Figure 3. Statewide series completion was 76.6% (95% CI, 74.4-78.7). No region was statistically significantly different from the statewide completion rate. Southeast region, Knox County region, and Northeast Region were the only regions with point-estimates meeting the HP2020 objective of 80%. Appendix 2 contains region-specific charts of coverage rates for each vaccine and the 4:3:1:FS:3:1:FS series.

Figure 3. Percent of 24 Month Old Children With On-Time 4:3:1:FS:3:1:FS Series, by Health Department Region (point estimate and 95% confidence intervals, n=1468)



Progress towards Healthy People 2020 Objectives

In 2019, Tennessee met HP2020 objectives for three of the 12 vaccinations evaluated: polio (91.0%), hepatitis B (91.4%), and PCV (91.9%). The HP2020 objective for HAV is based upon completion of the two-dose series; however, TN only measures one dose of HAV because children who receive the first dose by their 2nd birthday may wait up to 18 months to receive dose two. As a result, the survey rate is not comparable to the HAV HP2020 objective.

In 2019, Tennessee met three HP2020 objectives compared to five out of 12 in 2018. While Tennessee maintained HP2020 objectives of greater than 90% completion for both polio and hepatitis B vaccines, MMR vaccination dropped from 90.1% to 88.3% and varicella dropped from 90.3% to 87.3%. Completion rate for PCV increased from 82.4% to 91.9%.

Tennessee did not met the HP2020 objective of 80% completion of the 4:3:1:FS:3:1:FS series in any year of the past decade. The majority of vaccine coverage rates decreased over the past decade. Polio and hepatitis B are the only vaccination rates that remained above the HP2020 objective of 90% for the entire decade. MMR, varicella, and HIB rates achieved HP2020 objectives at some point within the past decade but did not meet objectives in 2019. Flu and DTaP are the only two vaccines that have consistently been below the HP2020 objective every year of the past decade. With the exception of 2019, PCV was also below the HP2020 objective every. Notable increases in both HIB and PCV rates in 2019 are likely attributed to implementation of new completion logic which accounts for unique catch-up schedules.

Figure 4. Comparison of Healthy People 2020 objectives to Vaccination Completion Rates for 24 Month Old Children in Tennessee, 2019 (point estimate and 95% CI, n=1468)

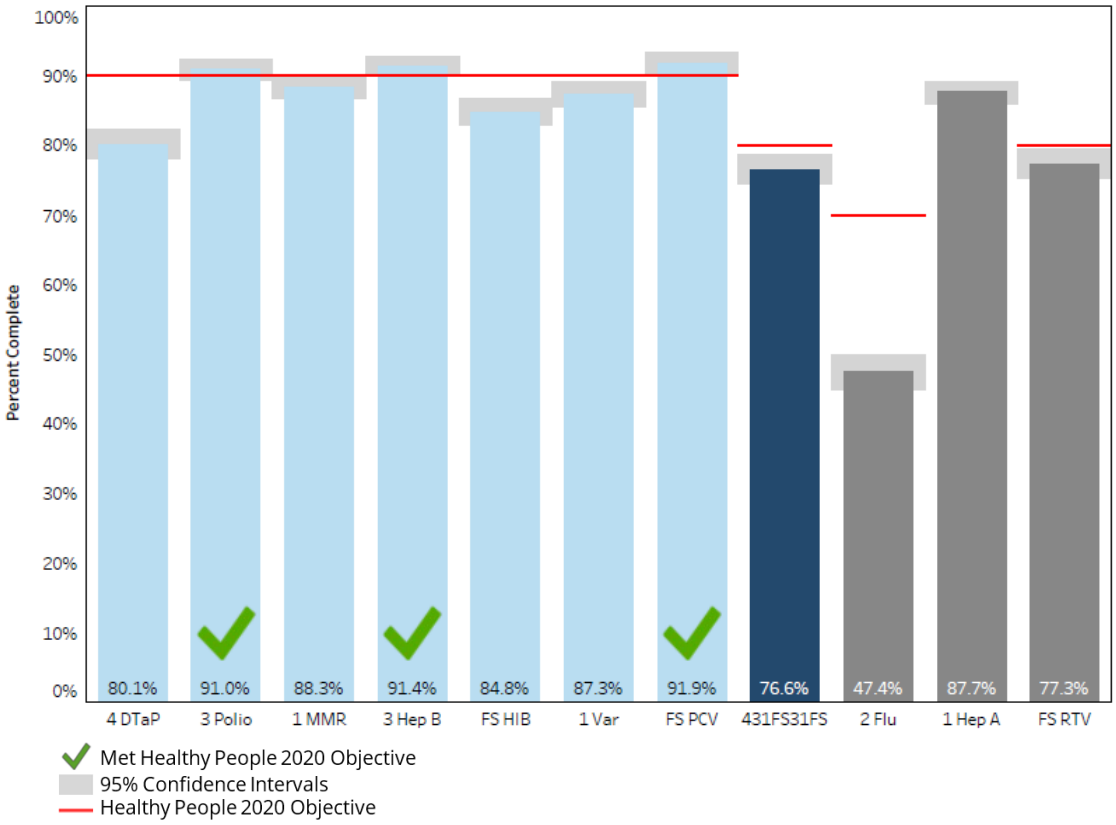


Figure 5. Statewide Trend of Complete 4:3:1:FS:3:1:FS Series, Tennessee, 2010-2019

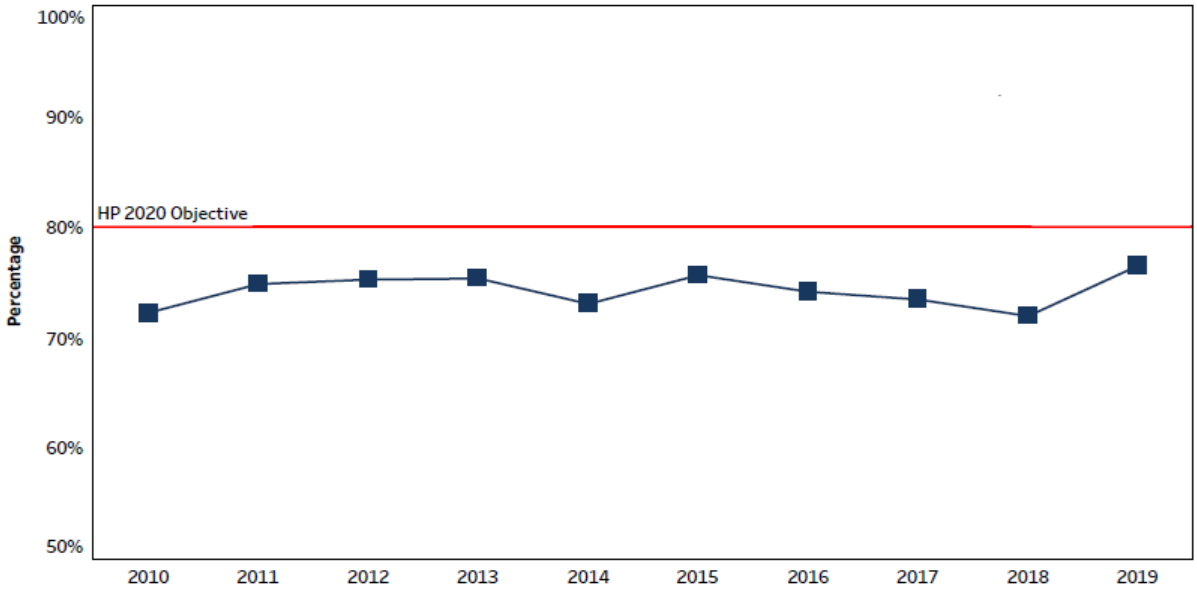


Figure 6. Statewide Trend of Complete Immunization for Individual Vaccines, Tennessee, 2010- 2019

[1]Decreases in RTV and HIB completion immunization rates from 2014 to 2015 likely due to change in methodology to account for vaccination brand

[2]Notable increase in HIB and PCV immunization rates in 2019 likely due to inclusion of children on CDC's catch-up schedule

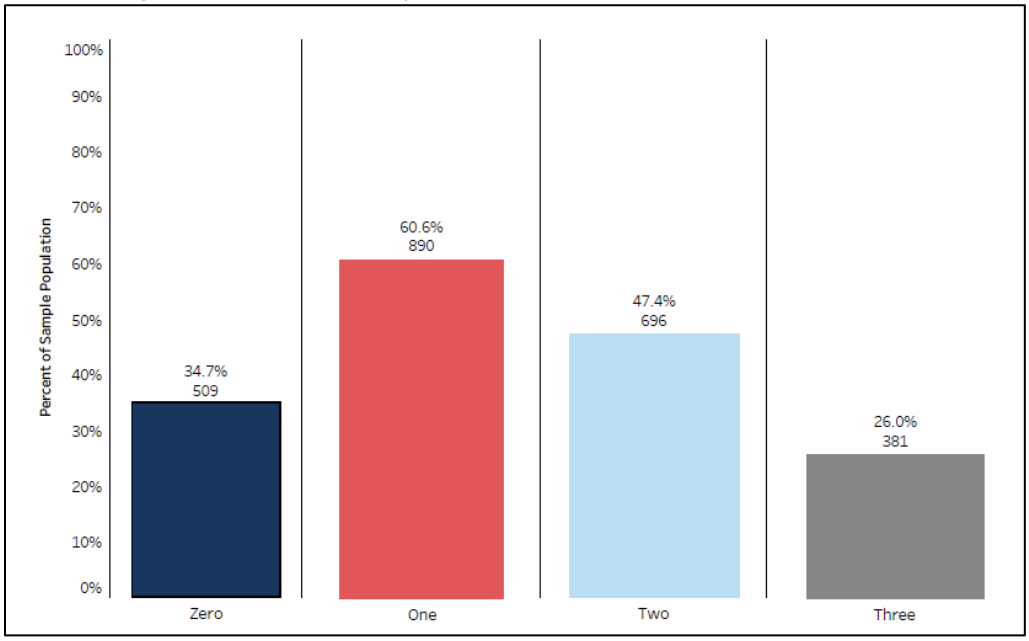
Seasonal Influenza Vaccination

Impact on Pediatric Morbidity and Mortality

Children younger than 2 years old are at high risk of developing serious flu-related complications. These complications include pneumonia, dehydration, acerbation of chronic illnesses (such as asthma), brain dysfunction (encephalopathy), and death. During the 2017-18 flu season, 187 children were reported as dying from influenza within the United States; however, the CDC estimates that number may be as high as 600 children.[10]

The annual seasonal influenza vaccine helps save lives. Influenza vaccine was shown to reduce the risk of pediatric intensive care unit (PICU) admissions by 74% from 2010-2012. During the 2017-18 flu season, proper flu vaccination of all people prevented an estimated 6.2 million influenza illnesses, 3.2 million influenza-associated medical visits, 91,000 hospitalizations, and 5,700 influenza associated deaths[11]. Despite its benefits, influenza vaccine remains the least administered of the recommended immunizations in Tennessee. 60.6% of all children surveyed had at least one dose of seasonal influenza vaccine, 47.4% had two, and 26.0% received the recommended three doses of influenza vaccine prior to the second birthday.

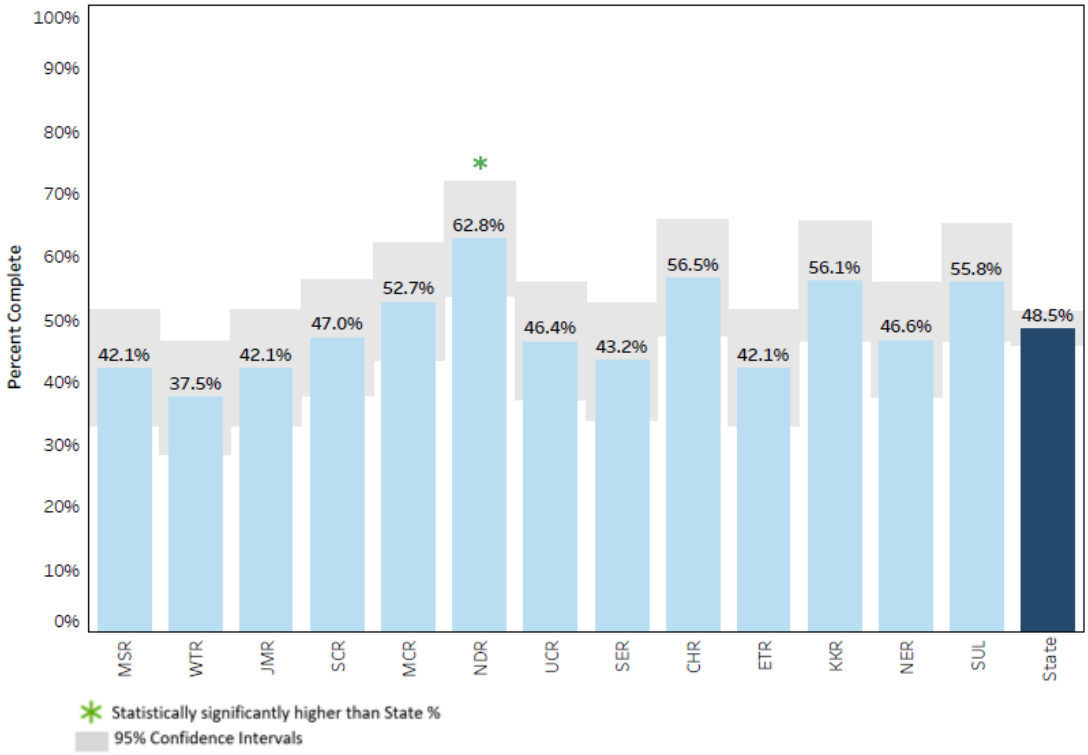
Figure 7. Percentage and Count of Children with Zero, One, Two, or Three Seasonal Influenza Vaccine in the First 24 Months of Age, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



Seasonal Influenza Vaccine in First Year of Life

Of the 1,468 children surveyed, 48.5% (95% CI: 45.9-51.0) received their first flu vaccine between 6 months and one year of age. Nashville-Davidson region was the only health department region with statistically significantly more children who received their first dose of influenza vaccine between 6 months and one year of age (62.8%, 95%CI: 53.8-77.9) compared to Tennessee as a whole.

Figure 8. Percentage of Children Who Received First Dose of Influenza Vaccine in First Year of Life, by Health Department Region, Tennessee, 2019 (point estimate and 95% CI, n=1468)



Racial Disparity

All racial analysis reports include the 21 oversampled children. The 2019 survey population included 266 black and 1,194 white children. Due to small numbers, children of other races (n= 29) were excluded from this analysis. This survey does not differentiate between Hispanic whites and non-Hispanic whites; for that reason, racial disparity involving Hispanic ethnicity was not analyzed. The final sample for racial analysis consisted of 1,460 children.

Black children were less likely to be fully immunized for six of the twelve recommended CDC vaccinations and statistically significantly less immunized against Flu and RTV compared to their white peers. Only 70.7% of black children were properly immunized with RTV vaccine compared to 78.8% of white children, and 35.3% of black children were immunized against influenza compared to 50% of white children.

Of the 1,194 white children, 77.3% (95% CI: 74.9-79.7) completed the 4:3:1:FS:3:1:FS series, while 73.3% (95%CI: 67.9-78.7) of the 266 black children completed the series. 2018 was the first time in the last five years in which there was a decrease in the racial disparity of 4:3:1:FS:3:1:FS immunization rates between black and white children; this trend continued in 2019.

The racial disparity in the overall 4:3:1:FS:3:1:FS series was driven by the disparity in the DTaP completion rates. Black children were less likely to be fully immunized on time with DTaP (75.6% black vs. 81.1% white), although this difference was not statistically significant. 2019 was the first year that black children had a higher rate of PCV immunization than whites, with 93.6% complete vs 91.8% of white children; this could suggest more black children are being vaccinated after the ACIP recommended age but before their second birthday.

Black children also had higher vaccination completion rates for polio and hepatitis B than did whites; 91.3% compared to 91.0% for polio and 93.2% compared to and 91.1% for hepatitis B, respectively.

Figure 9. Statewide Percentage of Children with Age-Appropriate Immunization Rates, by Vaccine and Race, Tennessee, 2019 (point estimates and 95% Confidence Intervals)

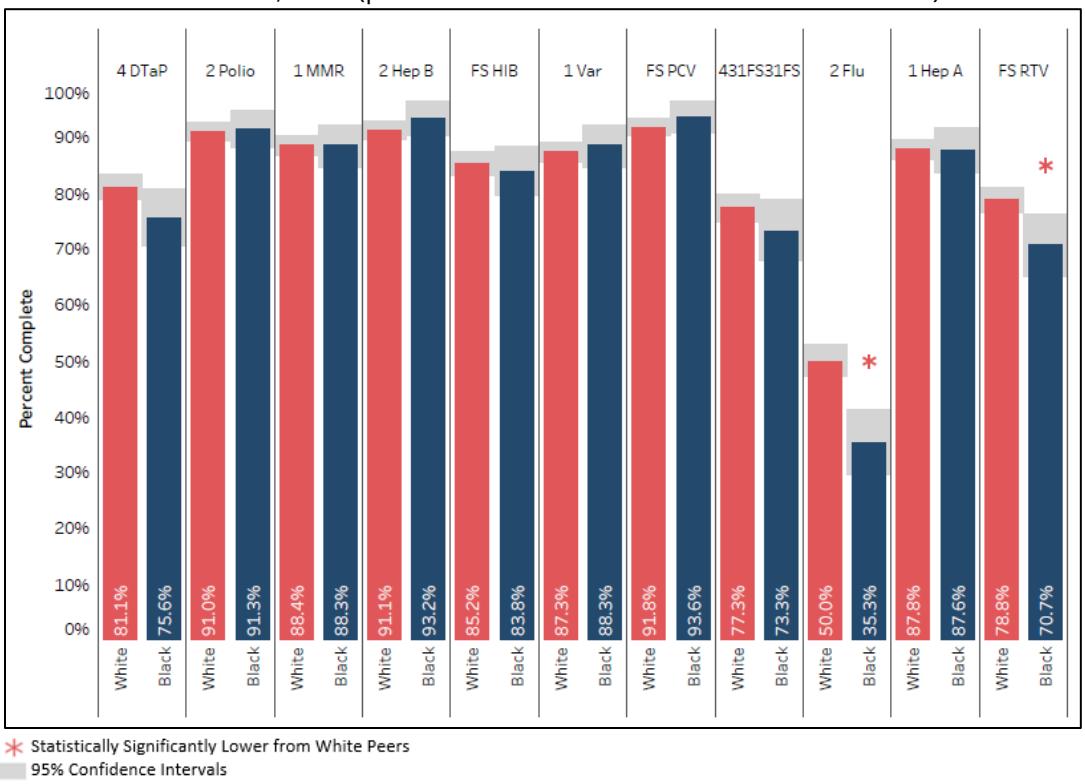
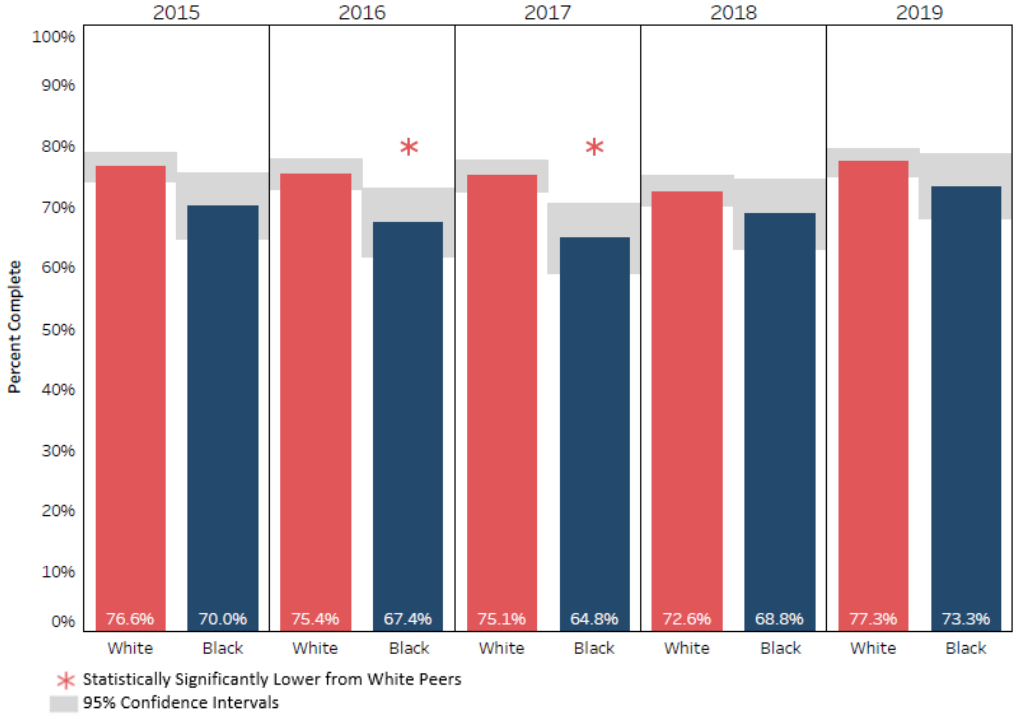
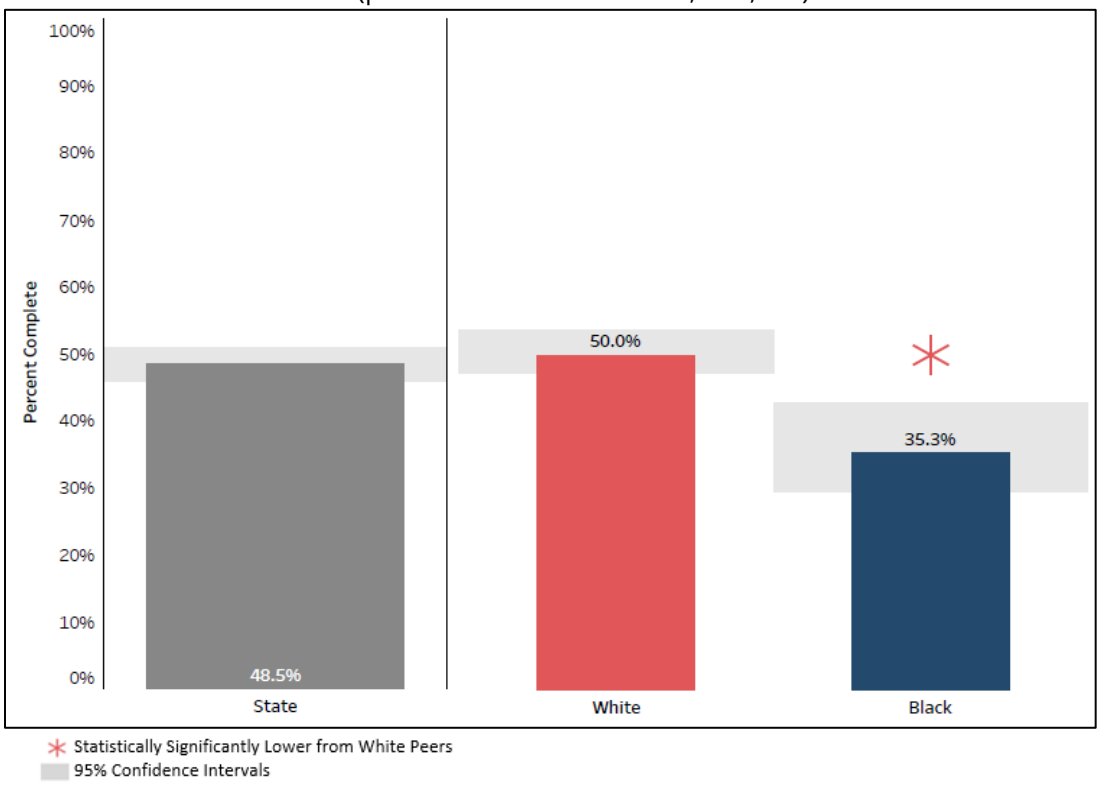


Figure 10. 4:3:1:FS:3:1:FS Immunization Level Rates, by Race, Tennessee, 2015- 2019 (point estimate and 95% CI)



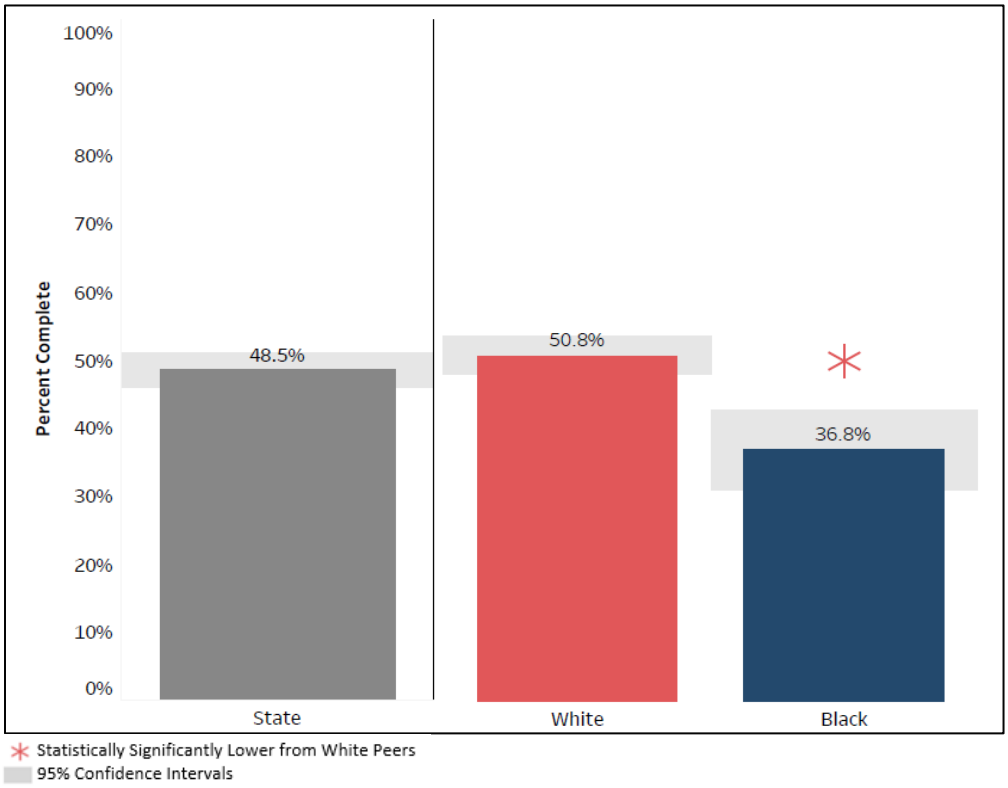
Influenza remains the individual vaccine with the most significant racial disparity. This difference has been documented annually since the first assessment of influenza coverage rates in 2007. In 2019, 35.3% (95% CI: 29.6-42.7) of black children received at least two doses of influenza vaccine compared to 50.0% (95% CI: 47.2-53.6) of white children.

Figure 11. Statewide Percentage of Children with Two-Doses of Seasonal Influenza Vaccine, by Race, Tennessee, 2019 (point estimate and 95% CI, n=1,460)



The ACIP recommends all children over the age of 6 months receive annual influenza vaccine. Of the 1,468 surveyed children, 48.5% received their first dose between 6 months and one year of age. White children were more likely to receive their first dose of influenza vaccine before their first birthday than black children (50.8% compared to 36.8%, respectively).

Figure 12. Percentage of Children Who Received First Influenza Vaccination in First Year of Life, by Race (point estimate and 95% CI, n=1460)



Risk Factor Analysis

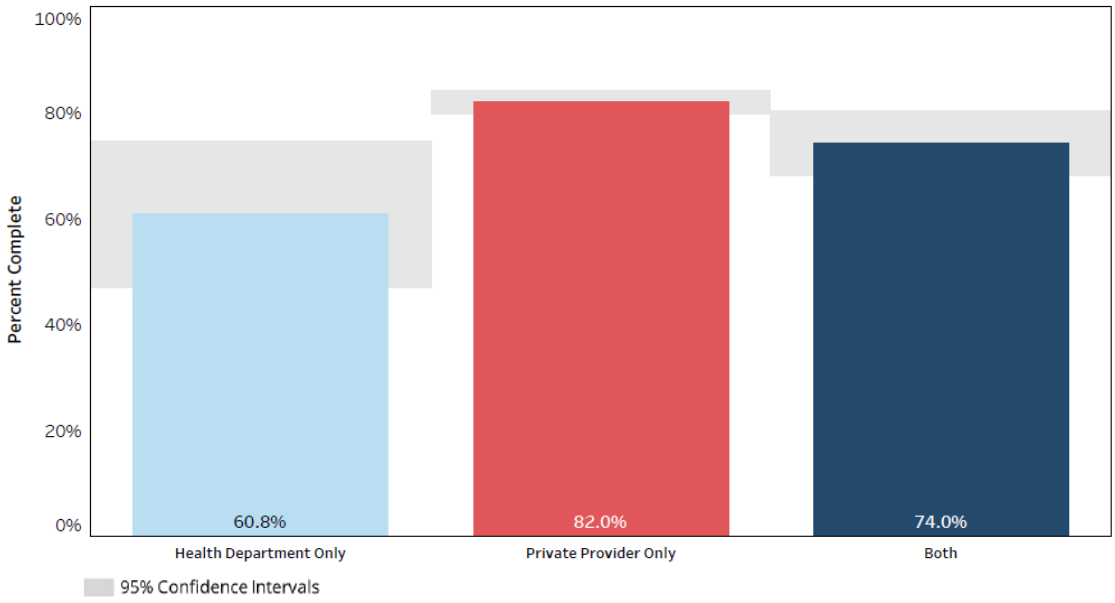
Insurance Enrollment

Of the 1,468 children included in this survey, 949 (64.6%) were enrolled in TennCare, 830 (56.5%) were enrolled in WIC, and 766 (52.2%) were enrolled in both programs. The numbers of children enrolled in TennCare and WIC are not mutually exclusive of each other. In 2019, children who were covered by TennCare and WIC had 4:3:1:FS:3:1:FS series completion rates that were not significantly different from their non-enrolled peers. Of those enrolled in TennCare, 77.7% (95% CI: 75.0-80.3) were fully immunized, compared to 74.6% (95% CI: 70.8-78.3) of those not enrolled in TennCare. Similarly, 75.3% (95% CI: 72.4-78.2) of WIC enrollees were complete for the full 4:3:1:FS:3:1:FS series compared to 78.2% (95% CI: 75.0-81.4) of those not enrolled in WIC.

Immunization Source

1138 (81.9%) children sampled were immunized by a private medical provider, 200 (14.4%) children sampled were immunized by a health department only, and 51 (3.7%) children sampled were immunized by both a private provider and a health department. Children who received vaccines exclusively from a private provider were statistically significantly more likely to be fully vaccinated (82.0%) compared to children vaccinated by a health department only (60.8%) or by a combination of private provider and health department (74.0%).

Figure 13. Comparison of Children Complete for the 4:3:1:FS:3:1:FS Series by Immunization Provider Type, Tennessee, 2019 (point estimate and 95% confidence intervals, n=1468)



Children immunized in health departments were more likely to have risk factors for failure to receive immunizations compared to children who were only immunized by private providers. These risk factors include black race, having two or more siblings and receipt of a first dose of any vaccine (except RTV and birth dose of hepatitis B) after the 120th day of life.

Table 6. Prevalence of Three Risk Factors for Delayed Immunizations, by Provider Type

	Black Race	2 or More Siblings	Age at first dose >120 days*	Any Risk Factor
Immunized Exclusively by Health Department	31.4% (16/51)	43.1% (22/51)	2.0% (1/51)	60.8% (31/51)
Immunized Exclusively by Private Provider	14.9% (169/1138)	23.8% (271/1138)	1.1% (13/1138)	34.8% (396/1138)
Immunized by Health Department and Private Provider	27.0% (54/200)	38.0% (76/200)	4% (8/200)	53.5% (107/200)

*excluding RTV and birth dose of Hep B

Impact of Age at First Immunization on Immunization Completion

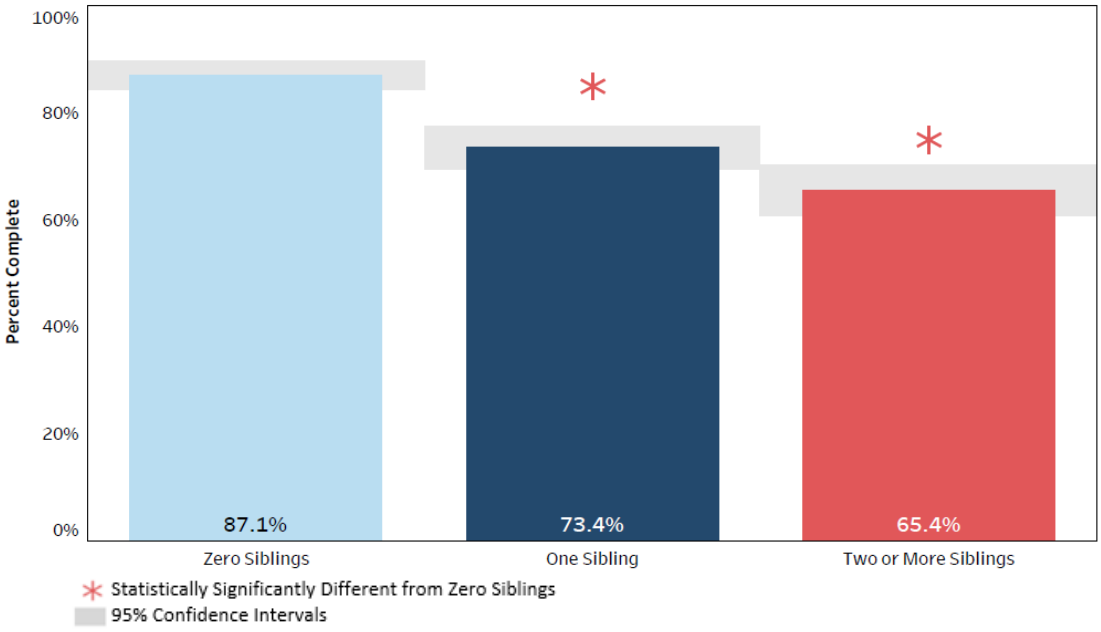
Children who do not receive immunizations prior to 4 months of age are at risk of being under vaccinated. Of the children surveyed, 98.8% (1,111) began immunizations prior to 4 months of age and 80.6% of those children were completely immunized for the 4:3:1:FS:3:1:FS series by 24 months of age, compared to 59.1% (n= 13) of the 22 children who began immunizations after 4 months of age.

Impact of Siblings on Immunization Completion

Of the 1,468 children included in the survey, 573 (39.0%) had no siblings, 493 (33.6%) had one sibling, and 402 (27.4%) had two or more siblings. As the number of siblings increased, there was a statistically significant decrease in the percentage of children who were complete for the 4:3:1:FS:3:1:FS series. While 87.1% (95% CI:

84.3-89.8) of children with no siblings were complete, only 73.4% (95% CI: 69.5-77.3) with one sibling and 65.4% (95% CI: 60.7-70.0) with two or more siblings achieved series completion.

Figure 14. Comparison of Children Complete for the 4:3:1:FS:3:1:FS Series with Zero, One, or Two or More Siblings (point estimate and 95% confidence intervals, n=1468)

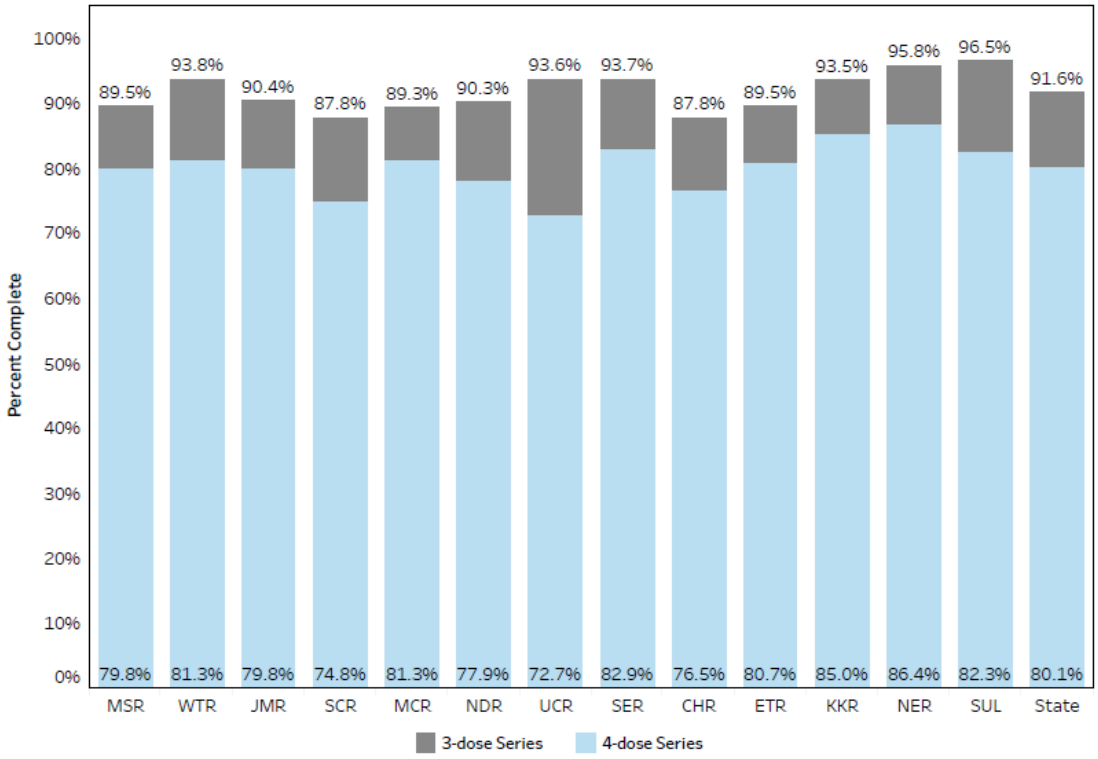


Opportunities for Improvement

Fourth DTaP

Figure 15 compares the regional percentages of children immunized with three and four doses of DTaP vaccine. The complete DTaP immunization rates for Tennessee was 80.1% (95% CI: 78.0-82.1); however, 91.6% (95% CI: 90.2-93.0) of children had at least three doses of DTaP. The regional differences between receipt of three doses of DTaP vaccine compared to receipt of four doses of DTaP vaccine ranges from 8.0% to 20.9%. In order for a child to be properly protected against diphtheria, tetanus, and pertussis, a 4th dose of DTaP is necessary between 15-18 months of age. If all children who had received 3 doses of DTaP had received their fourth dose, Tennessee would have met the HP2020 objective for DTaP immunization (90%).

Figure 15. Percentage of Children with Complete Diphtheria, Tetanus, Pertussis (DTaP) Three Dose vs Four Dose Series by Health Department Region, TN, 2019 (point estimates and 95% confidence intervals, n=1468)



CDC Catch-up vs ACIP schedule

In 2019, a change in completion logic was made to account for children who began HIB or PCV vaccination outside of the ACIP-recommended age but prior to 24 months. 305 (20.8%) of the 1,468 children surveyed were vaccinated according to a catch-up schedule. Of these, 147 (48.2%) were considered complete for HIB vaccine. Of the 204 children vaccinated with PCV after the CDC recommended age, 180 (61.2%) were considered complete for PCV vaccine. When the catch-up schedule is considered, Tennessee exceeds the HP2020 objective for PCV vaccine coverage.

Figure 16. Percentage of Children with Complete HIB Series, by CDC Schedule, by Health Department Region, Tennessee, 2019 (n=1468)

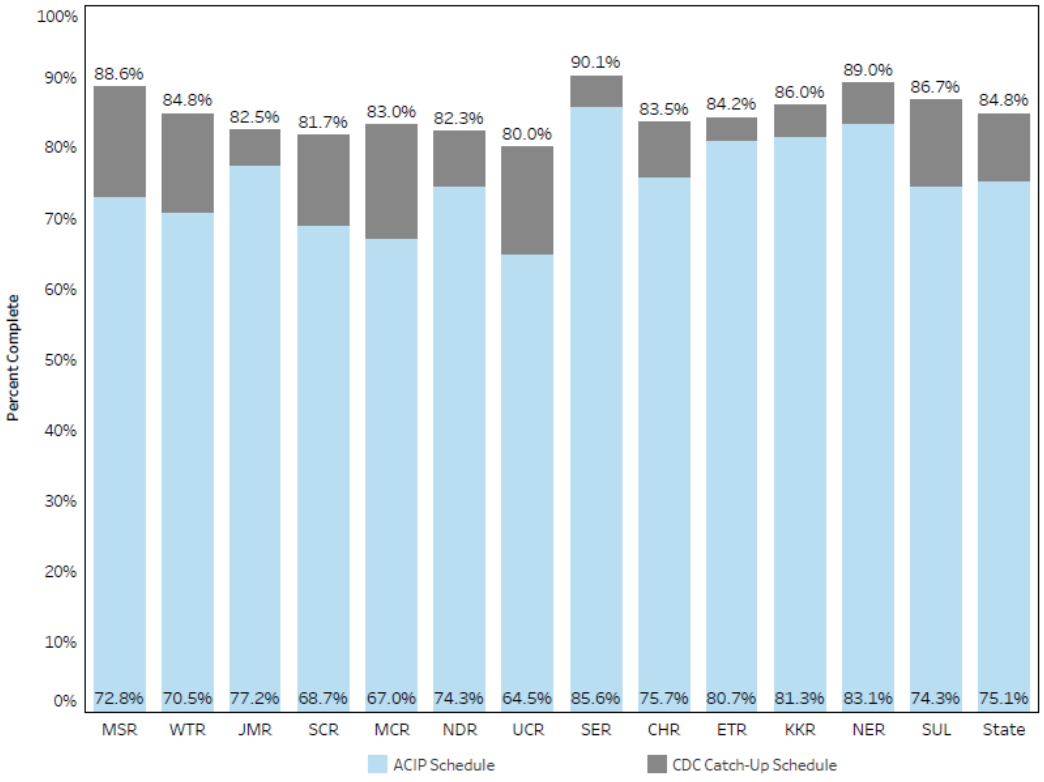
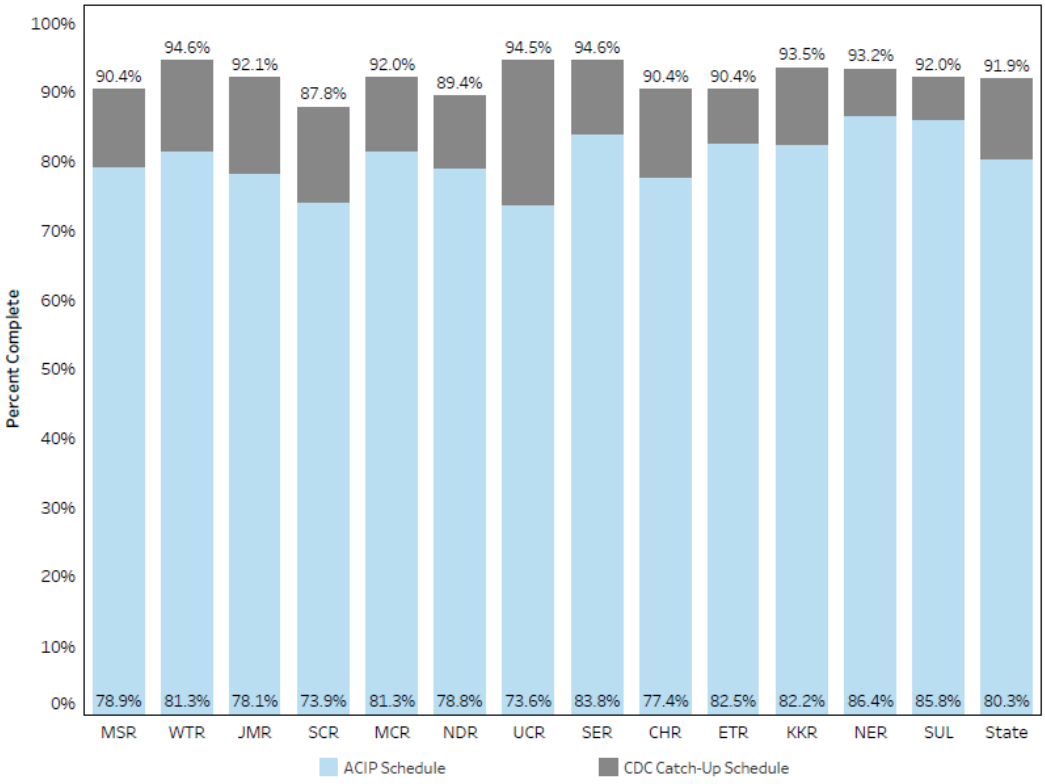


Figure 17. Percentage of Children with Complete PCV Series, by CDC Schedule, by Health Department Region, Tennessee, 2019 (n=1468)



Summary of Key Findings

Below is the summary of coverage rates relative to Health People (HP) 2020 objectives:

Measurement	HP2020 objective (19-35 months)	TN 2019 (24 months)
Complete 4:3:1:FS:3:1:4 series	80%	76.6%
Each vaccine in 4:3:1:FS:3:1:4 (DTaP, IPV, MMR, Hib, HBV, VAR, PCV)	90% rate for each of the 7 vaccines	**Exceeded 90% for 3:** 3 doses of IPV: 91.0% 3 doses of HBV: 91.4% Full series of PCV: 91.9% **Below 90% for 4:** 4 doses of DTaP (80.1%) 1 dose of MMR (88.3%) Full series of HIB (84.8%) 1 dose of Varicella (87.3%)
Hepatitis A vaccine	N/A	1 dose HAV (87.7%) *not comparable to HP2020*
Influenza vaccine	70% appropriately immunized	47.7% with 2 doses 26.0% with 3 doses
Rotavirus vaccine	80% with 2 doses	77.3%
Hepatitis B birth dose	85%	81.4%
3 doses DTaP vs 4 doses of DTaP	N/A	91.0% (3 DTaP) vs 80.1% (4 DTaP)
HIB Completion ACIP vs CDC Catch-Up	N/A	75.1% (ACIP) vs 84.8% (Catch-up)
PCV Completion ACIP vs CDC Catch-Up	N/A	80.3% (ACIP) vs 91.9% (Catch-Up)

- Tennessee's statewide completion of the 4:3:1:FS:1:3:FS full series would exceed the HP2020 coverage goal of 80% if the children sampled in this survey had received an additional immunization visit in their second year of life to receive a fourth dose of DTaP vaccine.
- Tennessee has not met HP2020 objectives for the 4:3:1:FS:3:1:FS at any point in the past decade; polio and hepatitis B have remained above the HP2020 objective of 90% for the entire decade
- Black children were statistically significantly less likely than white children to be completely immunized for RTV and Flu. Black children were more likely to be completely immunized for PCV compared to their white peers.
- 4.2% of surveyed parents reported refusing some or all immunizations, compared to 3.2% of parents in 2018. There has been a trend of increasing philosophical and religious exemptions for the past five years; this trend has also been observed in other states and is of concern due to the increased risk of vaccine-preventable disease among groups of unimmunized and under-immunized children.

Discussion

While overall vaccination rates among children in Tennessee remain high, the reintroduction of previously eliminated vaccine-preventable diseases across the United States emphasizes the importance of continued vigilance in ensuring that every medically-eligible child is fully vaccinated on-time and according to the Centers for Disease Control and Prevention (CDC) recommended childhood immunization schedule. Tennessee currently meets HP2020 targets for only four of 12 vaccination-related measures for 24 month old children.

The vast majority of parents in Tennessee vaccinate their children. Of the 1,468 children surveyed, 4.2% (61) reported objection or exemptions. Religious exemption was cited by 54% of those objecting immunizations, philosophical exemption was cited by 41% of those objecting immunizations, and medical exemption was cited by 5% of those objecting immunizations. As Tennessee law allows only religious and medical exemptions in lieu of complete immunization as required for public school entry, philosophical objections often transition to religious exemptions prior to school entry.

Three elements are critical to ensuring that every medically-eligible child in Tennessee is fully immunized on-time and according to the CDC's recommended childhood vaccination schedule:

- Parental and community education and messaging around the safety, efficacy and critical importance of childhood immunization
- Ready access to, and provision of, immunizations at every opportunity
- Reliable and readily accessible immunization records that ensure immunizations are provided on-time while avoiding duplication

Key Strategies for Improving Immunization Rates Among 24 Month Old Children

Parental and community education and messaging around the safety, efficacy and critical importance of childhood immunization

- Parents should be skeptical of information posted to social media and refer to credible sources vaccine information and their child's medical provider when seeking information about vaccines.
- The ability of public health and healthcare providers to provide a strong and credible message that "vaccines are safe, vaccines are effective, and vaccines save lives" is critical to ensuring the protection of Tennesseans of all ages.

Ready access to, and provision of, vaccinations at every opportunity

- The federally-funded Vaccines for Children (VFC) Program ensures that children who are covered by TennCare or otherwise lack insurance coverage for vaccines are able to receive them free of charge through a statewide network of healthcare providers and local departments of health. Expansion of this network of VFC Providers will provide more opportunities to vaccinate children.
- Providers should review vaccine records and administer missing vaccinations at every opportunity.
- The Tennessee Immunization Information System (TennIIS) is built with the ACIP forecaster for each child. Physicians should utilize TennIIS to identify gaps in immunizations, especially DTaP and Flu, at every opportunity.

Reliable and readily accessible vaccination records that ensure vaccinations are provided on-time while avoiding duplication

- The Tennessee Immunization Information System, "TennIIS" (www.TennesseeIIS.gov) is an online immunization registry that is available to all immunizing providers, including hospitals, clinics and

pharmacies, and includes a suite of tools which may help to improve immunization rates among children and adults.

- Standards implemented in 2017 require clinics participating in the federal Vaccines for Children (VFC) Program report all immunizations administered to children under 19 years of age to TennIIS. This enables providers to use system features designed to improve patient immunization services, such as vaccine forecasting, practice-based patient reminders and immunization coverage rate reports.
- Reporting all immunizations to an Immunization Information System (IIS) such as TennIIS improves healthcare by establishing a permanent immunization record that is available to all healthcare providers. TennIIS is linked to the electronic health record (EHR) systems of hundreds of medical facilities and pharmacies statewide, allowing for seamless electronic immunization record reporting from those systems.
- TennIIS provides providers with a validated immunization certificate, which families use for daycare, school, college entry, and employment requirements. Provider participation in TennIIS is critical to build these lifelong records.

Policy

- States that have eliminated non-medical exemptions have benefited from higher overall immunization rates than states which allow non-medical exemptions.

Recommendations to Improve Immunization Coverage in 24 Month Old Children

The following recommendations may improve on-time immunization of Tennessee children:

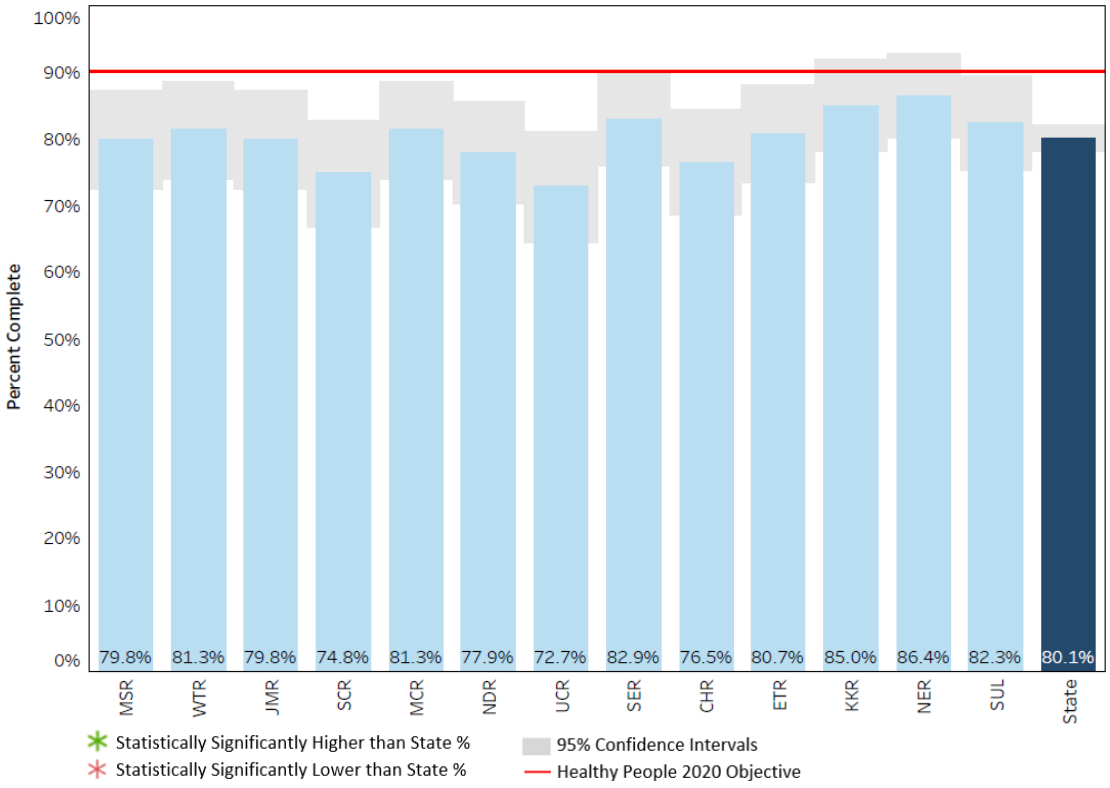
1. Provider practices should implement strategies that remind parents when their children are due or overdue for booster doses of DTaP, HIB and PCV. Most children who fell short of complete immunization could have achieved series completion with just one additional immunization visit prior to the second birthday. Minority children are especially vulnerable to missing immunizations.
2. Parents and providers should strictly adhere to the early infant schedule of immunizations at 2-, 4-, and 6-months. Doing so will enable providers to administer the 4th DTaP and all other needed immunizations as early as the first birthday, maximizing the number of opportunities to immunize children on time.
3. Providers should continue to strive to improve immunization rates. The Tennessee Immunization Information System (TennIIS) maintains patient immunization records and special tools which may assist providers in improving the quality of their immunization services. Use of user guides and other TennIIS resources available through the training information posted at www.TennesseeIIS.gov may assist providers in recognizing opportunities to immunize their patients.
    a. TennIIS provides individual patient forecasting of immunizations due, based upon the patient's immunization history.
    b. TennIIS is able to generate patient reminders through the use of manual, autodialer, text or other reminder methods. This feature assists providers in reminding patients of immunization appointments and recalling children who are due or overdue for immunizations.
    c. Practices may run their own practice-level immunization coverage reports based on their active patients in TennIIS. Coaching on the use of these reports is available in the training section of TennIIS.
    d. There are more than 5,600 private provider offices enrolled in TennIIS. All immunizing providers should enroll and report immunizations to TennIIS. This will allow for more accurate shared clinical decision making and the most complete immunization record for Tennesseans.
4. VPDIP provides local health departments (LHDs) with lists of children aged 20-24 months who have received immunizations in a LHD and whose records show they are incompletely immunized with DTaP vaccine. These reports facilitate LHD efforts to recall those children who are incompletely immunized.

5. Patients enrolled in WIC and TennCare should continue to receive immunization education, immunization record review, and immunization administration at every opportunity.
6. VPDIP will broadly communicate the results of this survey to public health leaders, VFC program participants and professional organizations, including immunizing providers. The VPDIP program should continue to identify opportunities to provide VFC providers with immunization education and strategies to improve immunization coverage across the state.
7. The importance of continuous quality improvement should be emphasized and providers should be encouraged to participate in individualized quality improvement. The VFC Quality Assurance team and immunization field staff in each regional and metro public health department provide practice-level quality assessments and feedback to VFC providers with the lowest rates of 4th DTaP completion.
8. The public should be continually reminded of the morbidity and mortality associated with seasonal influenza. Barriers to universal influenza immunization should be continuously addressed and eliminated.
9. VPDIP should continue to seek partnerships with external organizations, such as the Tennessee Chapter of the American Academy of Pediatrics, TennCare, and Federally Qualified Rural Health Clinics (FQHCs) to ensure every medically-eligible child is immunized on time.

[1] CDC. Vaccination Coverage by Age 24 Months Among Children Born in 2015 and 2016 – National immunization Survey-Child, United States, 2016-2018. Morbidity and Mortality Weekly Report, 68(41);913-918.
[2]CDC. Ensuring the Safety of Vaccines in the United States. Centers for Disease Control and Prevention. 2013 Feb 01.
[3]CDC. Parent's Guide to Childhood Immunizations; Part 3: More About Vaccines. Centers for Disease Control and Prevention: 22-29.
[4]CDC. Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013. Morbidity and Mortality Weekly Report. 63(16);352-355.
[5]CDC. Ten Great Public Health Achievements – United States 2001—2011. Morbidity and Mortality Weekly Report. 60(19);619-623.
[6]Pradke, V., Bednarczyk, R., et al. Association between Vaccine Refusal and Vaccine-Preventable Diseases in the United States: A Review of Measles and Pertussis. JAMA. 2016 Mar 15; 315(11):1149-1158.
[7]Flannery, B., Reynolds, S., et al. Influenza Vaccination Effectiveness against Pediatric Deaths: 2010-2014. Pediatrics. 2017, May; 139(5):e20164244.
[8] American Academy of Pediatrics. Recommended Child and Adolescent Immunization Schedule for ages 19 years or younger, United States, 2019. Centers for Disease Control and Prevention. https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html
[9] Recommended Child and Adolescent Immunization Schedule for Ages 18 Years or Younger–United States, 2019. Centers for Disease Control and Prevention. 2020 Jan 01.
[10]CDC. Children & Influenza (Flu). Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases: 2019 Oct 23.
[11]CDC. What Are the Benefits of Flu Vaccination? Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases: 2019 Dec 3.

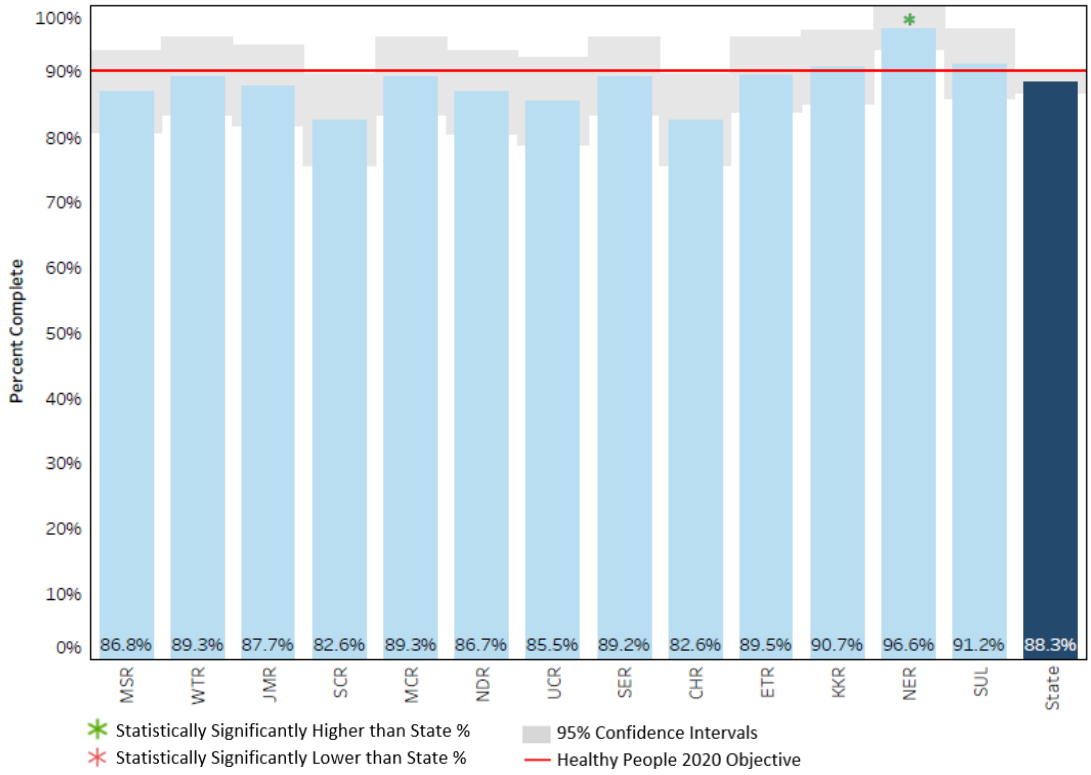
Appendix 1
Regional Antigen Specific Results

Percentage of Children with Complete **Diptheria, Tetanus, Pertussis (DTaP)** Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)

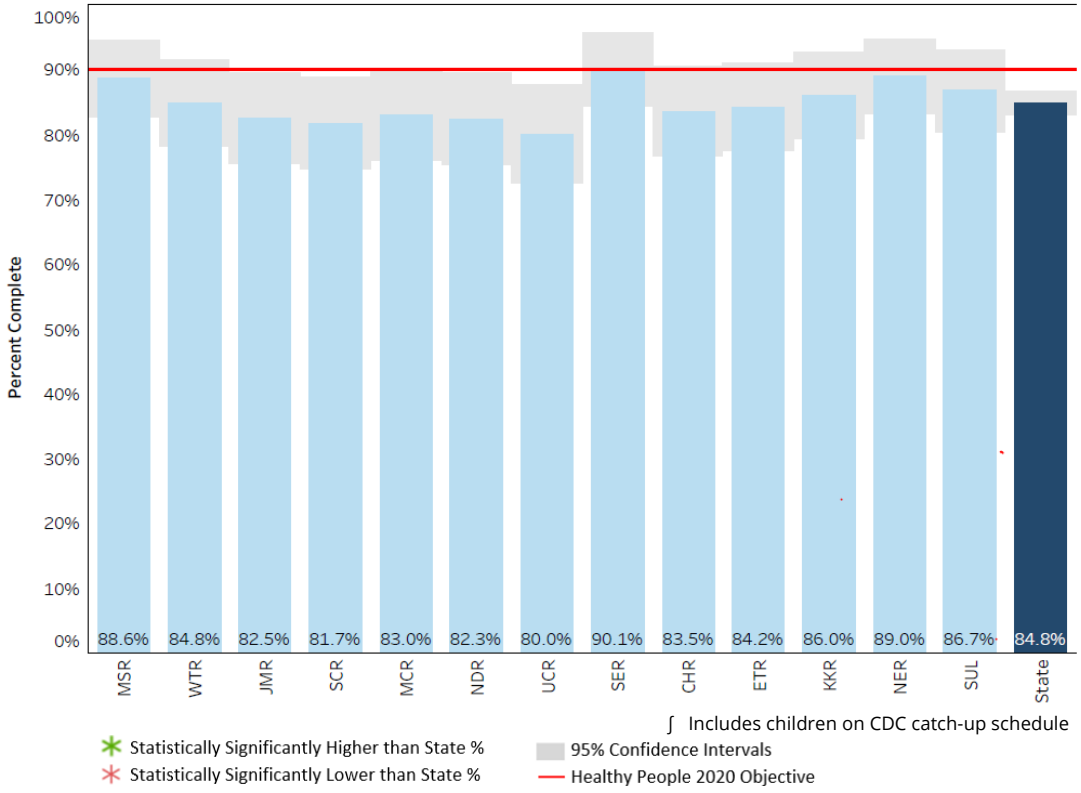


Percentage of Children with Complete **Polio (IPV)** Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)

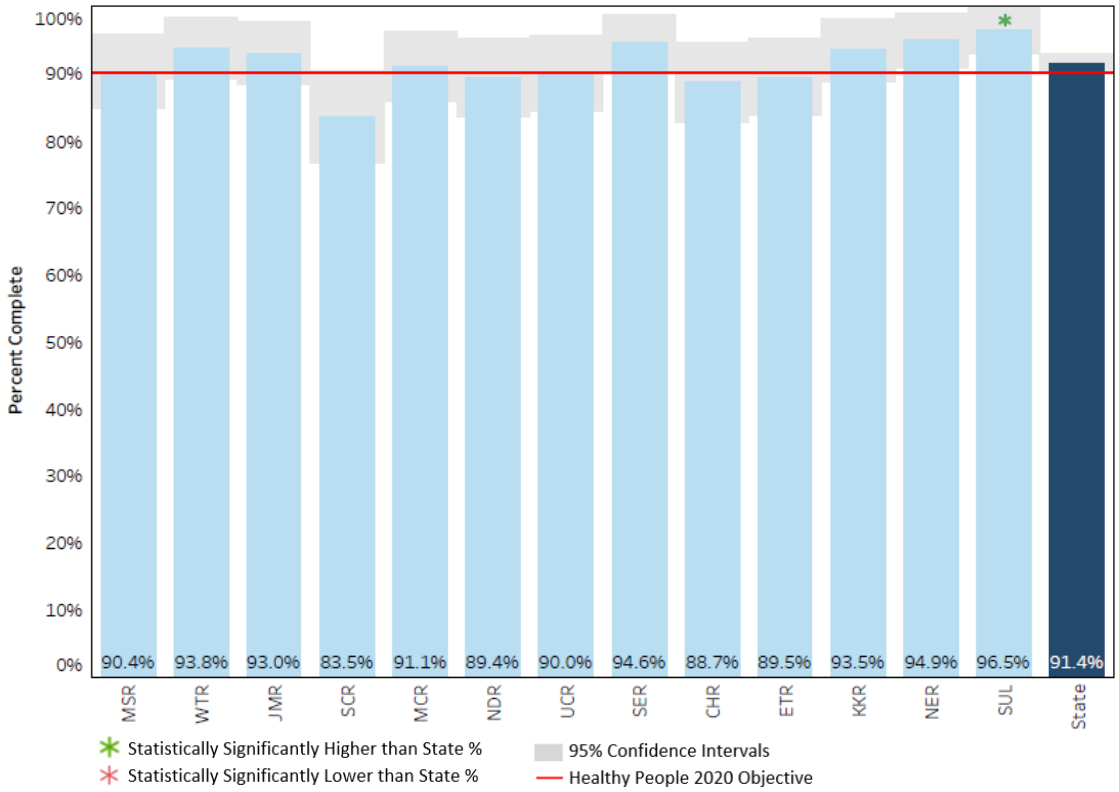
Percentage of Children with Complete **Measles, Mumps, Rubella (MMR)** by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



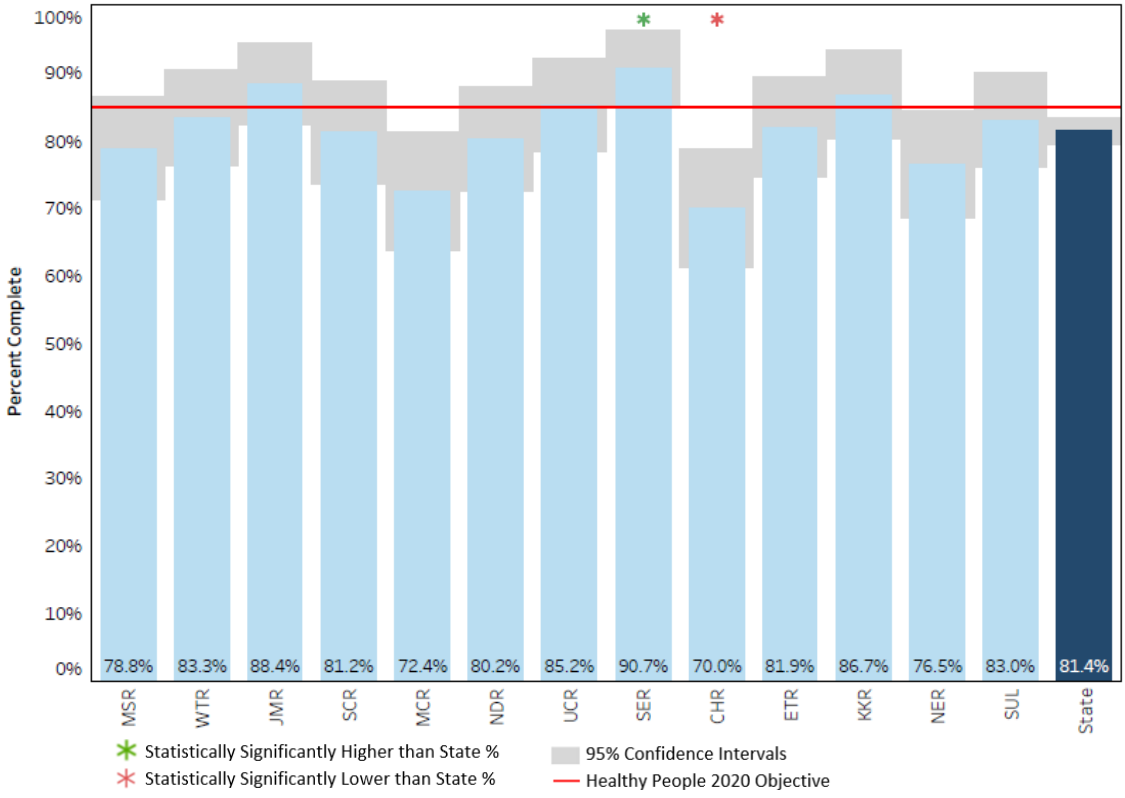
Percentage of Children with Complete **Haemophilus influenzae type B (HIB)**[ʃ] Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



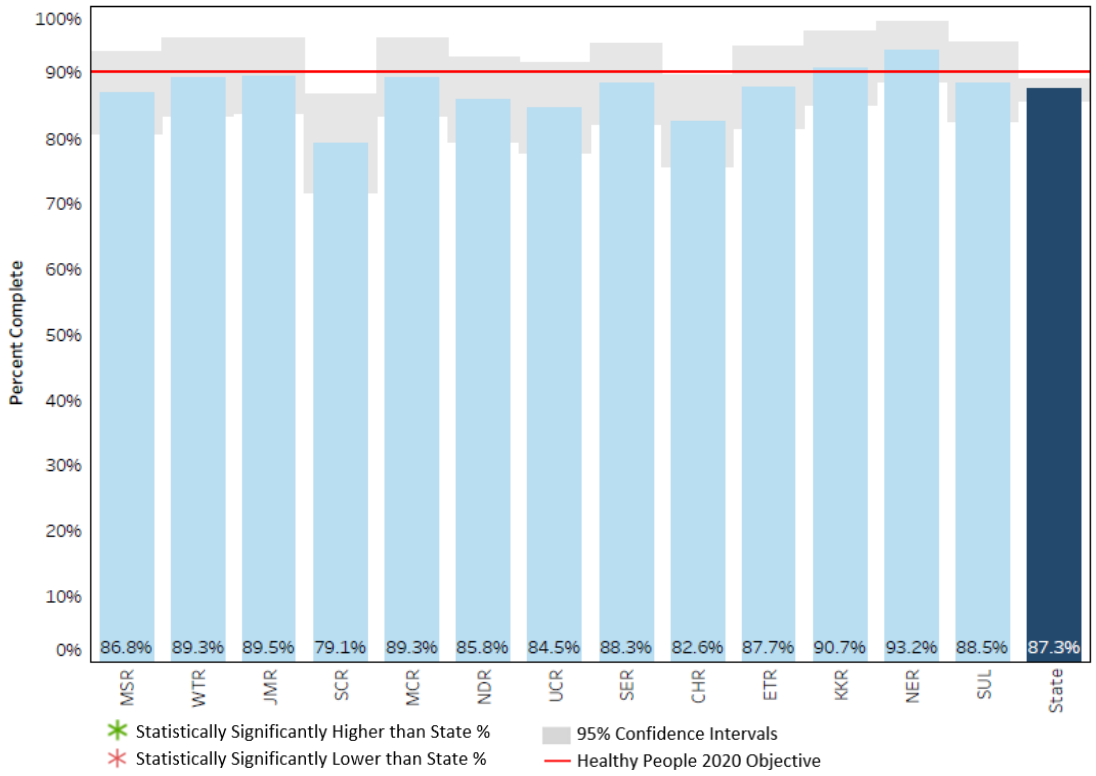
Percentage of Children with Complete **Hepatitis B (HBV)** Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



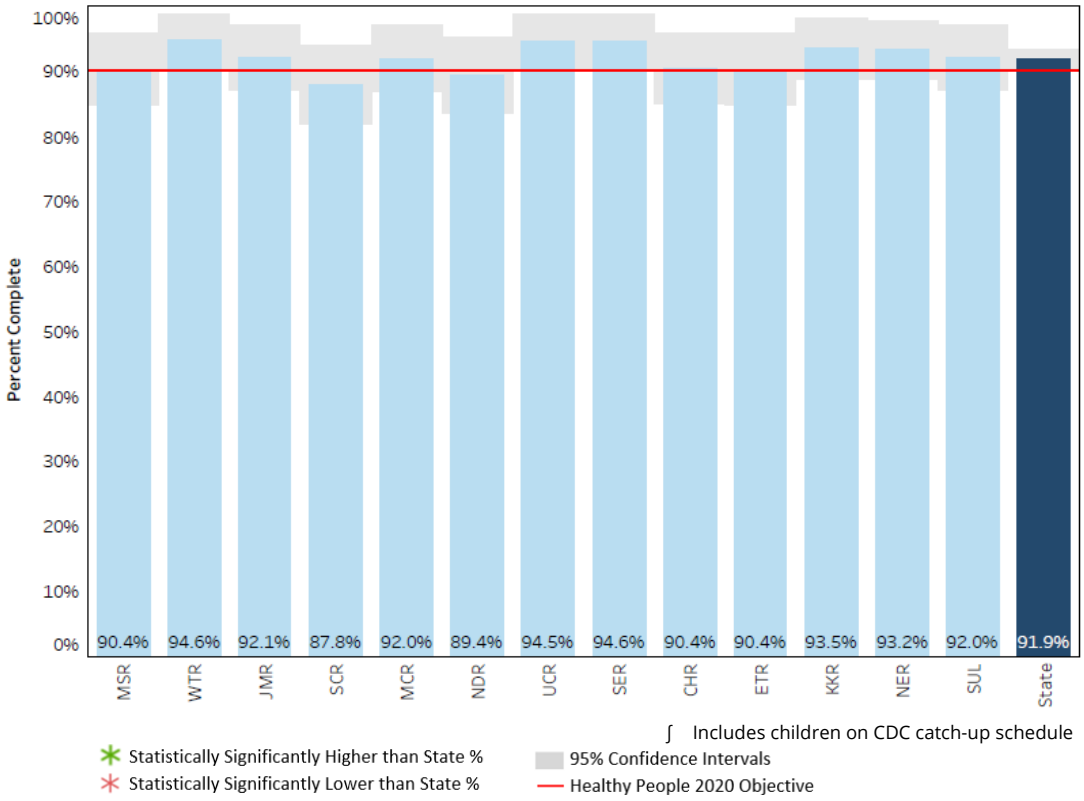
Percentage of Children with Complete **Birth Dose Hepatitis B (bHBV)** by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



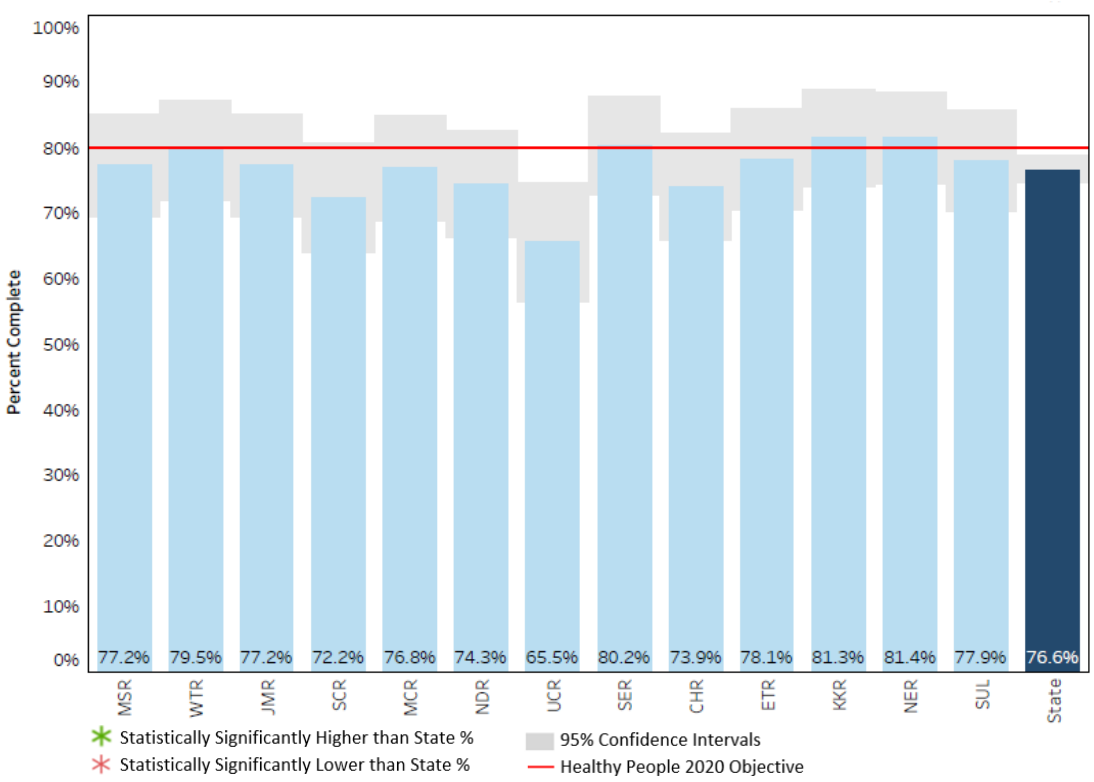
Percentage of Children with Complete **Varicella (VAX)** Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



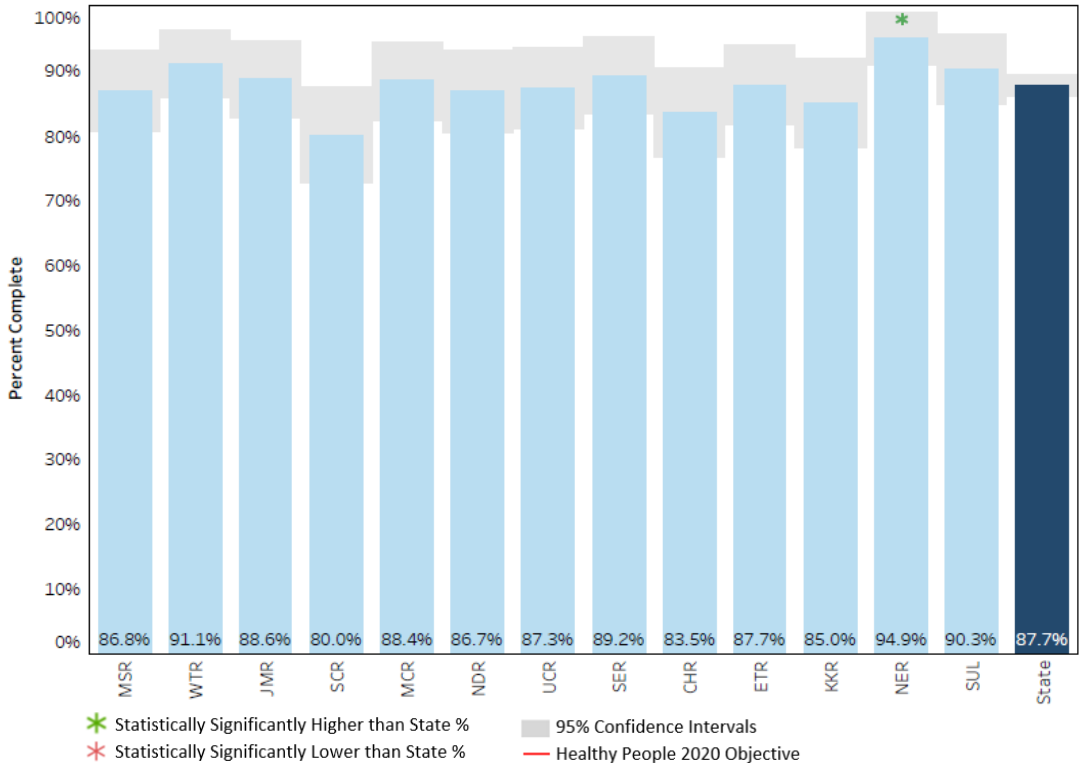
Percentage of Children with Complete **Pneumococcus (PCV)**∫ Series by Health Department Region, Tennessee, 2019 (point estimates and 95% confidence intervals, n=1468)



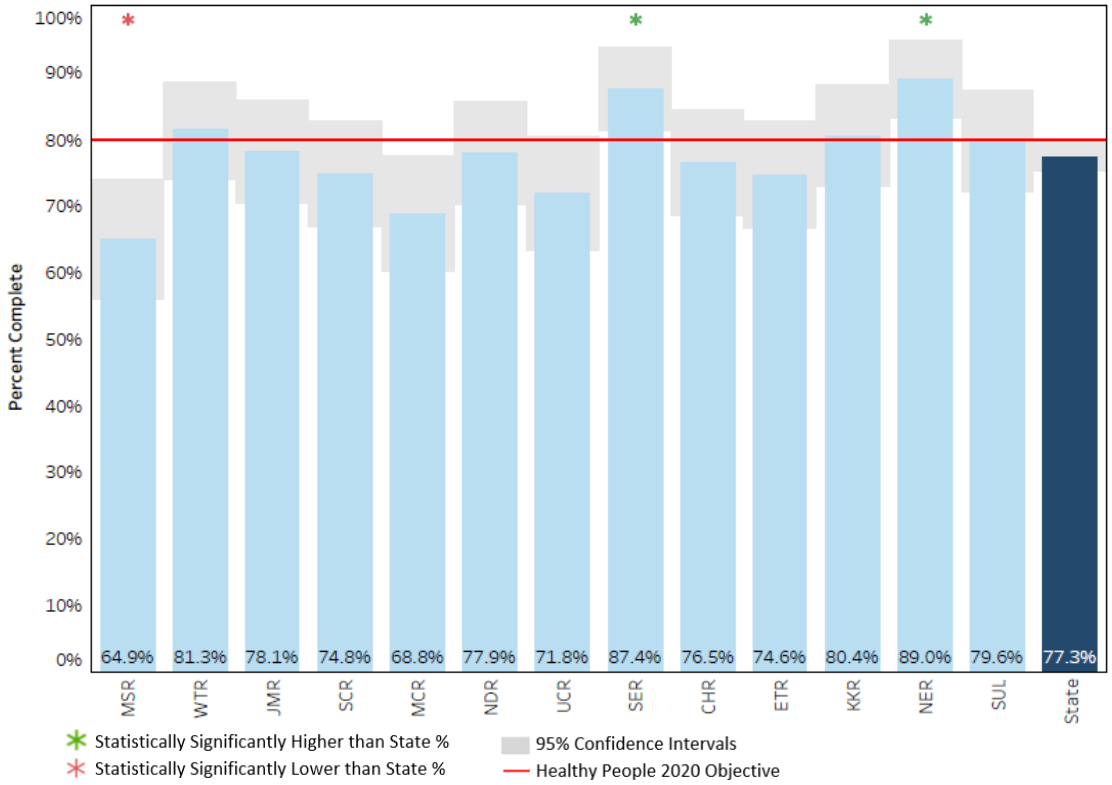
Percentage of Children with **Complete 4:3:1:FS:3:1:FS** Series by Health Department Region, Tennessee, 2019
(point estimates and 95% confidence intervals, n=1468)



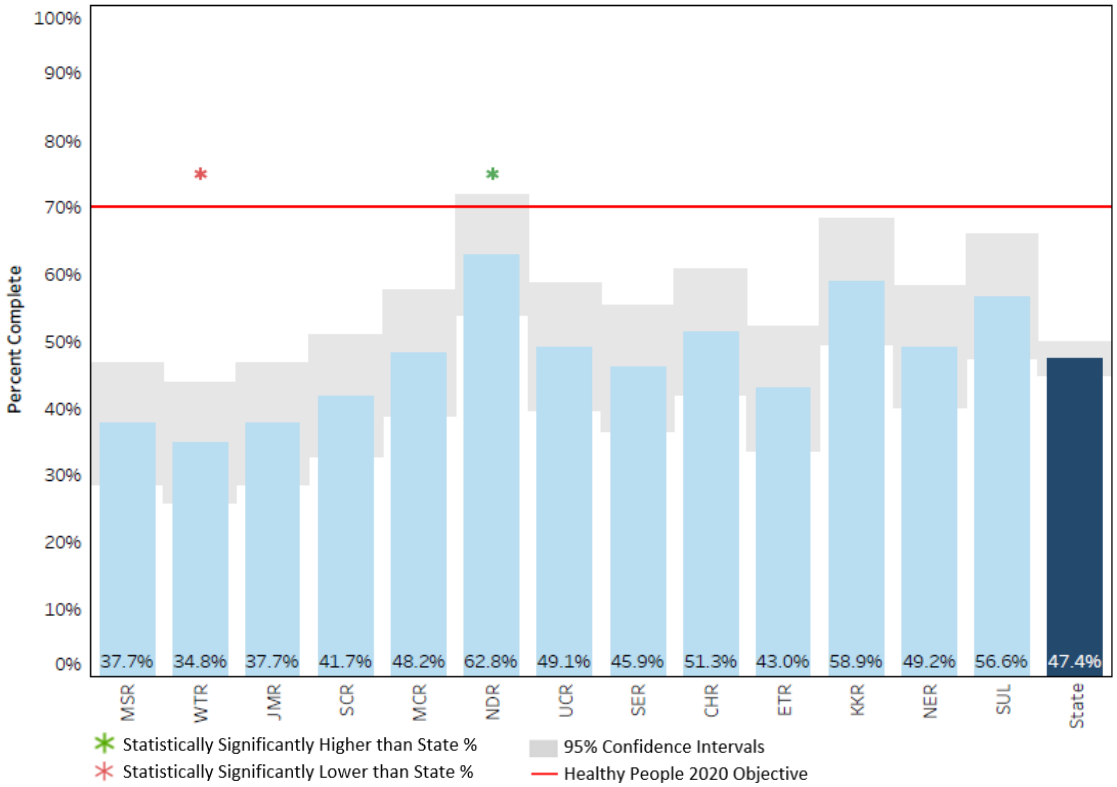
Percentage of Children with Complete **Hepatitis A (HAV)** Series by Health Department Region, Tennessee, 2019
(point estimates and 95% confidence intervals, n=1468)



Percentage of Children with Complete **Rotavirus (RTV)** Series by Health Department Region, Tennessee, 2019
(point estimates and 95% confidence intervals, n=1468)

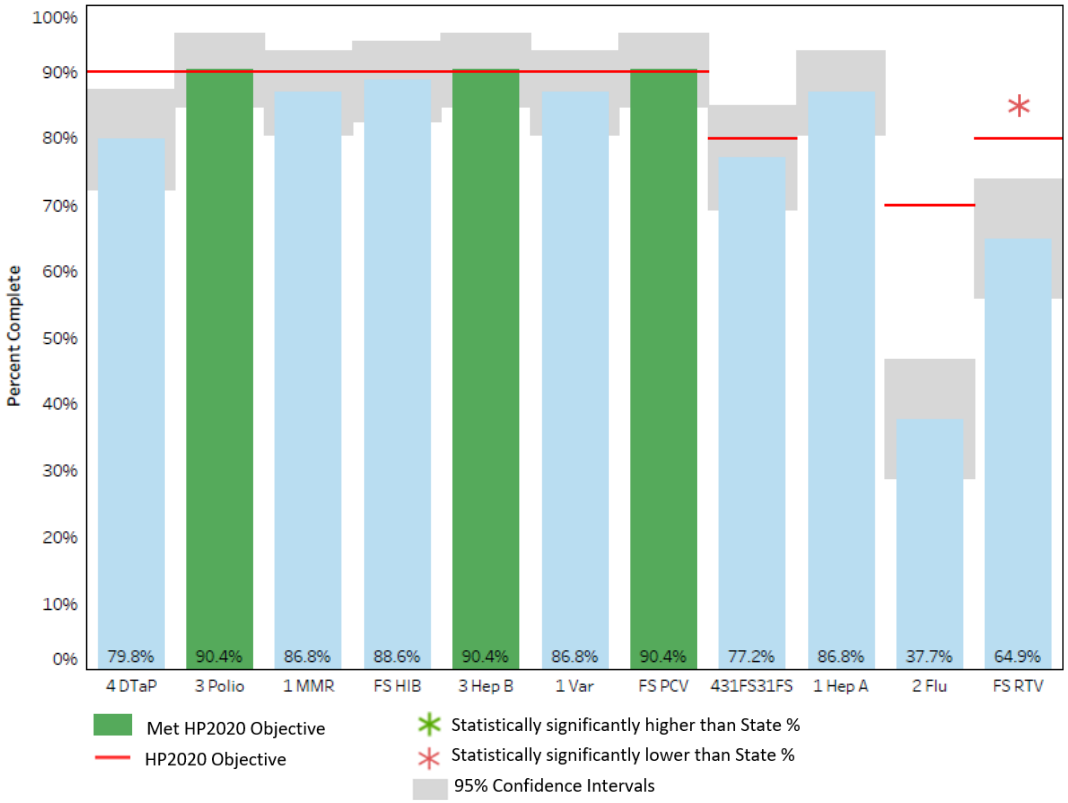


Percentage of Children with Complete **Influenza (FLU)** Series by Health Department Region, Tennessee, 2019
(point estimates and 95% confidence intervals, n=1468)

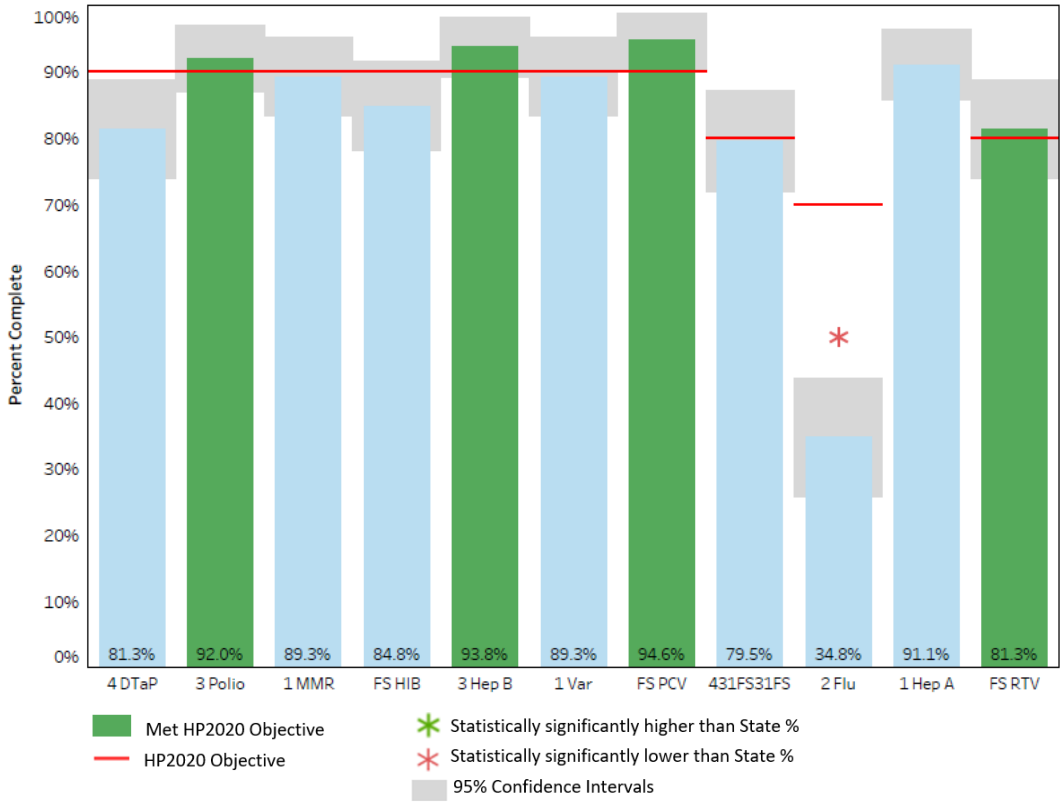


Appendix 2
Individual Health Department Region Charts with Coverage Rates for All Vaccines Assessed

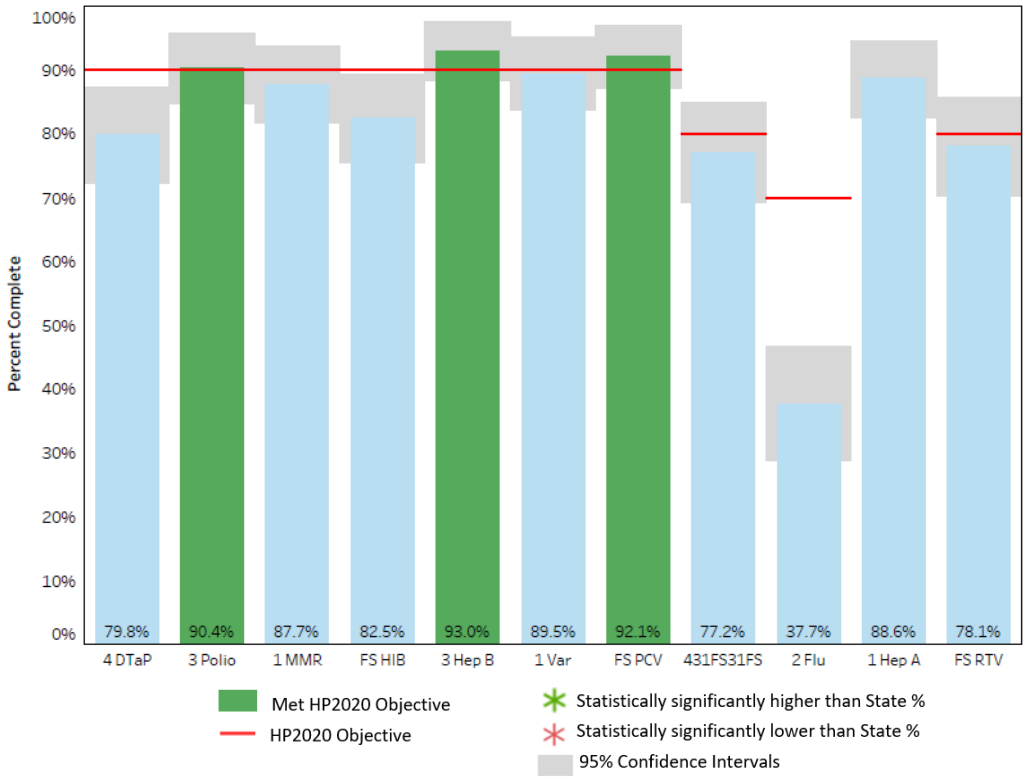
Percent of Children Complete in **Memphis-Shelby County (MSR)** by Vaccine (point estimates and 95% confidence intervals, n=114)



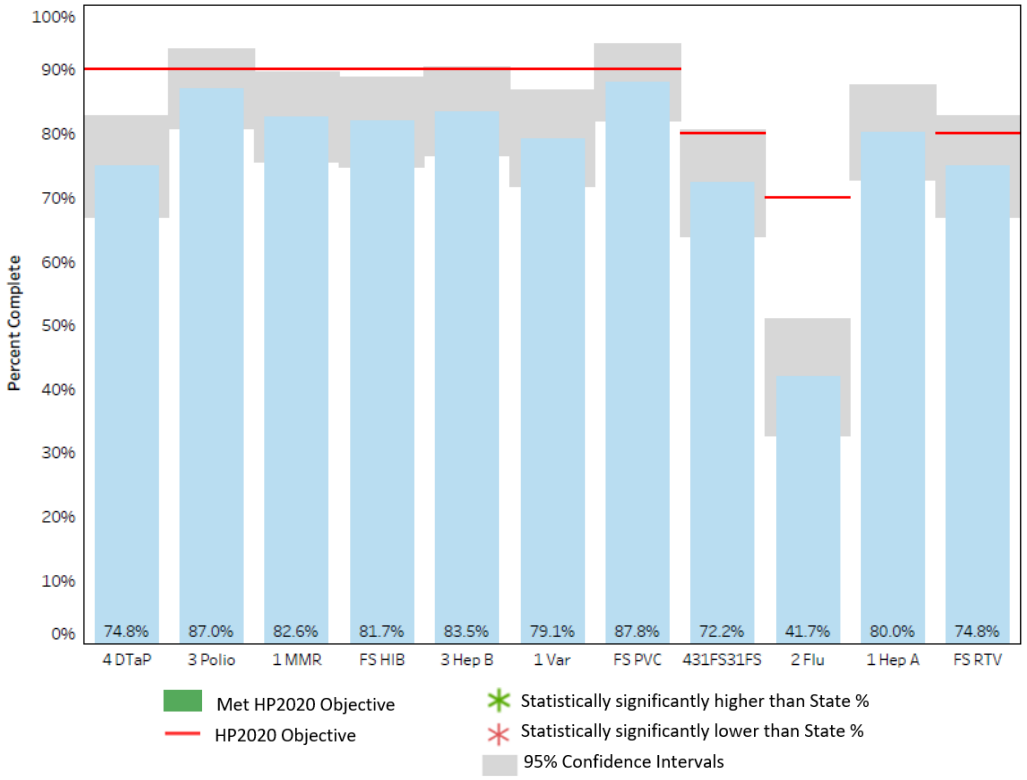
Percent of Children Complete in **West Tennessee Region (WTR)** by Vaccine (point estimates and 95% confidence intervals, n=113)



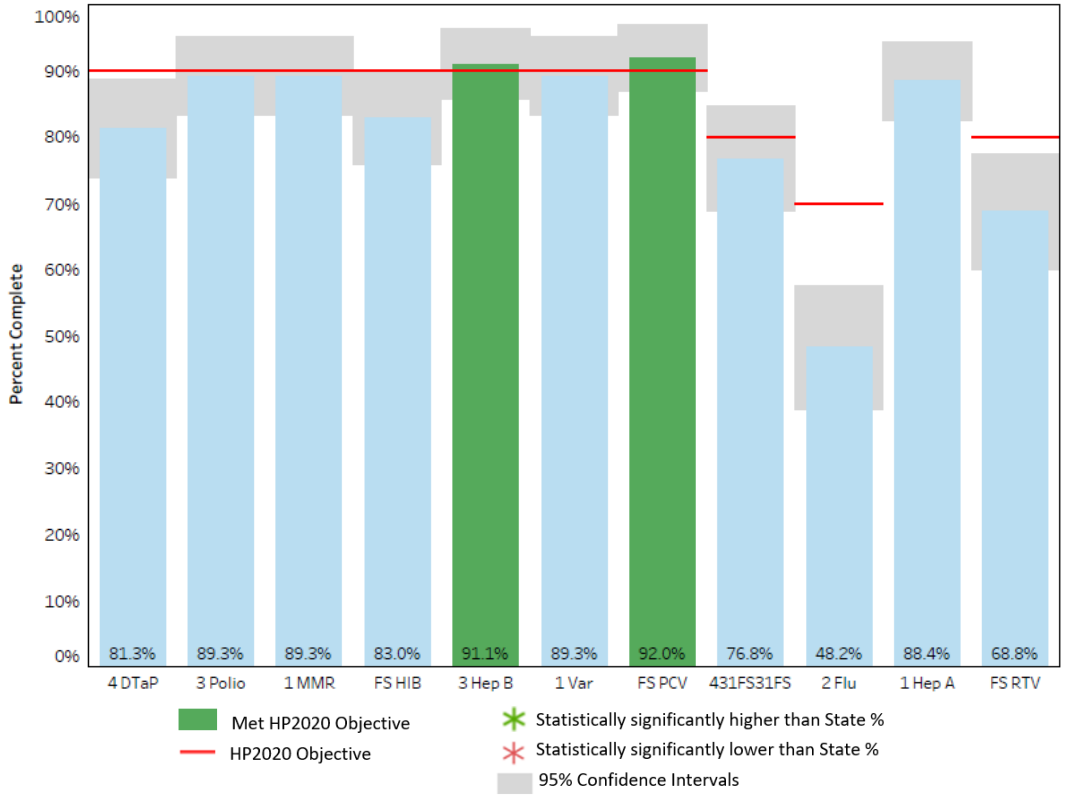
Percent of Children Complete in **Jackson-Madison Region (JMR)** by Vaccine (point estimates and 95% confidence intervals, n=114)



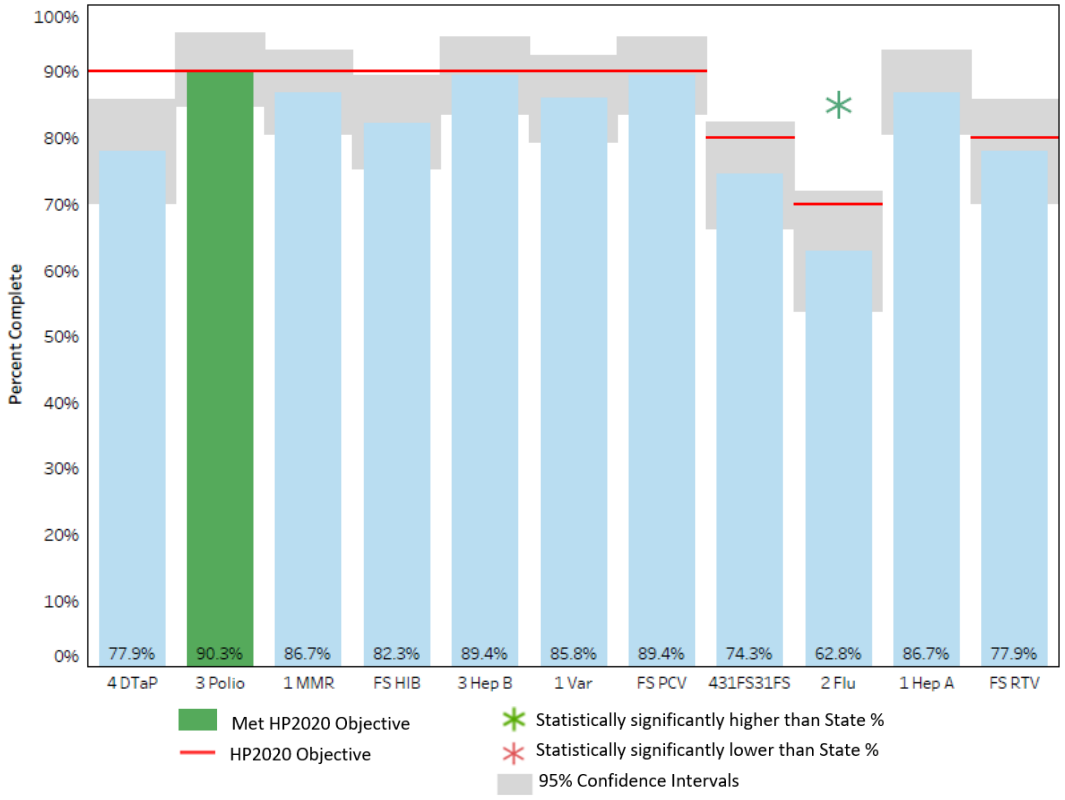
Percent of Children Complete in **South Central Region (SCR)** by Vaccine (point estimates and 95% confidence intervals, n=115)



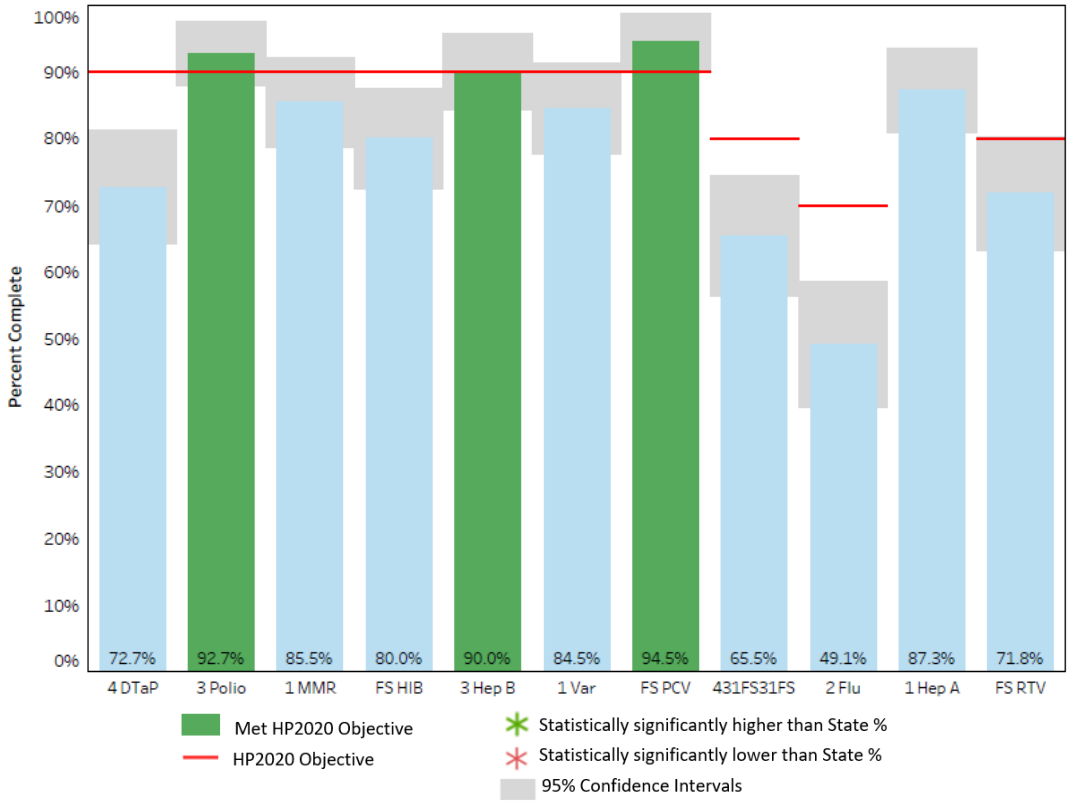
Percent of Children Complete in **Mid-Cumberland Region (MCR)** by Vaccine (point estimates and 95% confidence intervals, n=112)



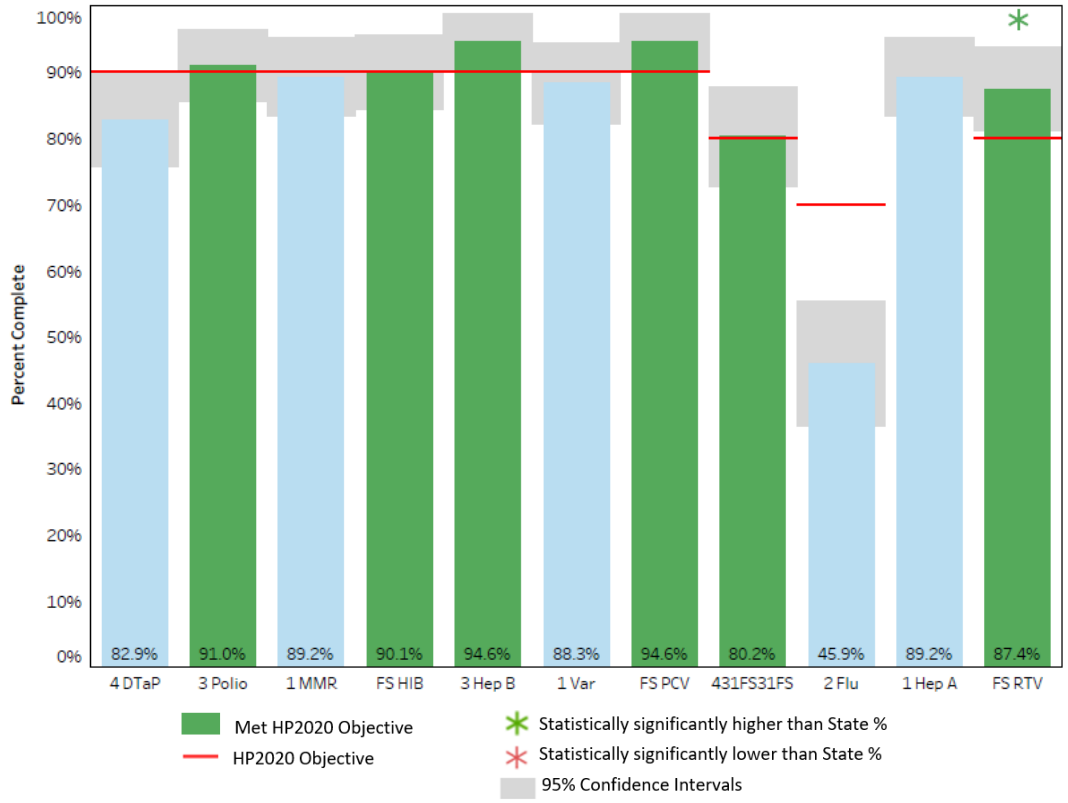
Percent of Children Complete in **Nashville-Davidson Region (NDR)** by Vaccine (point estimates and 95% confidence intervals, n=113)



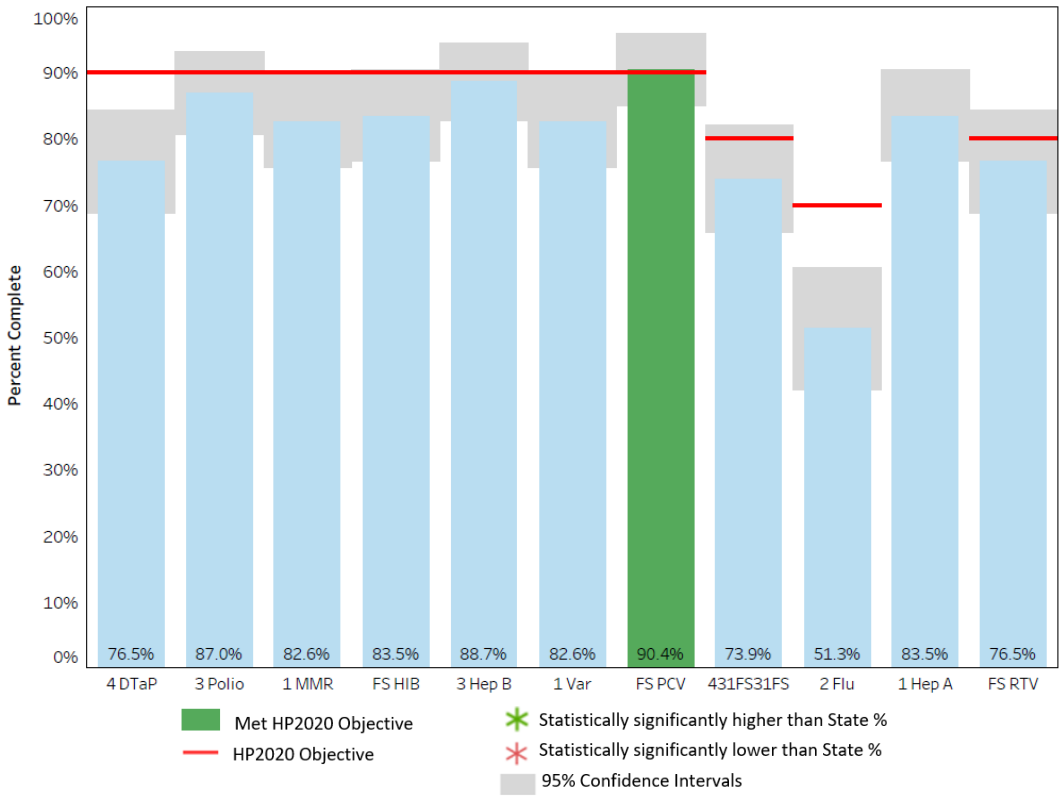
Percent of Children Complete in **Upper Cumberland Region (UCR)** by Vaccine (point estimates and 95% confidence intervals, n=110)



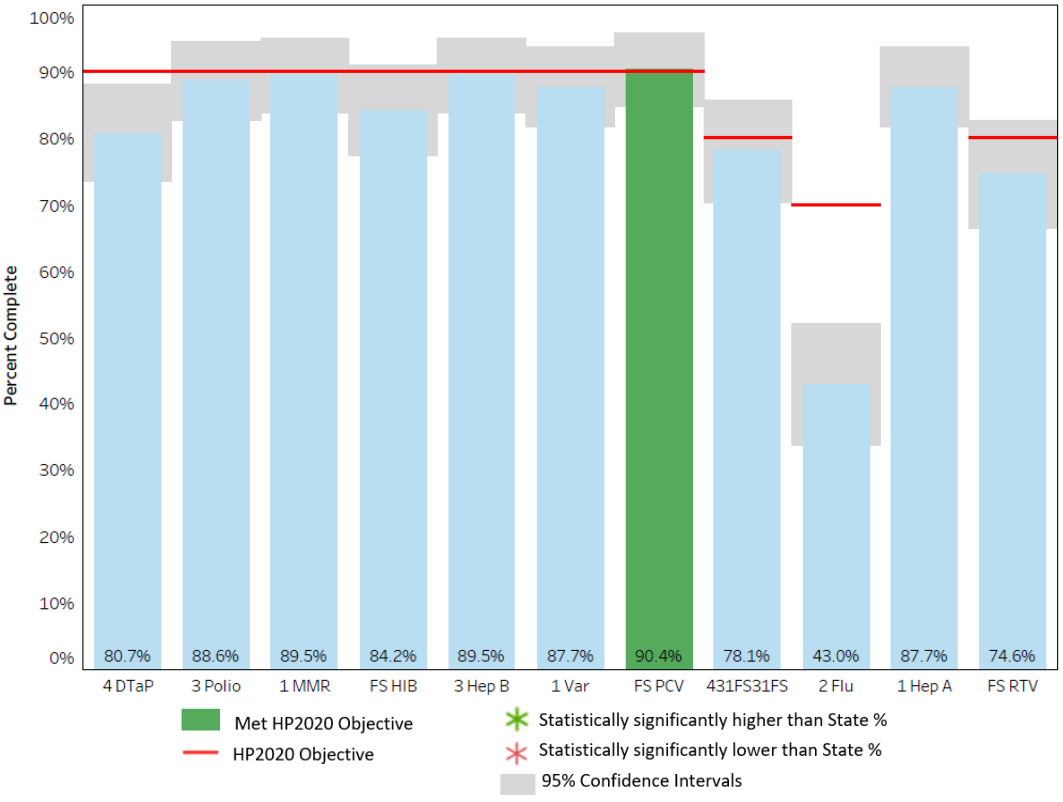
Percent of Children Complete in **Southeast Region (SER)** by Vaccine (point estimates and 95% confidence intervals, n=111)



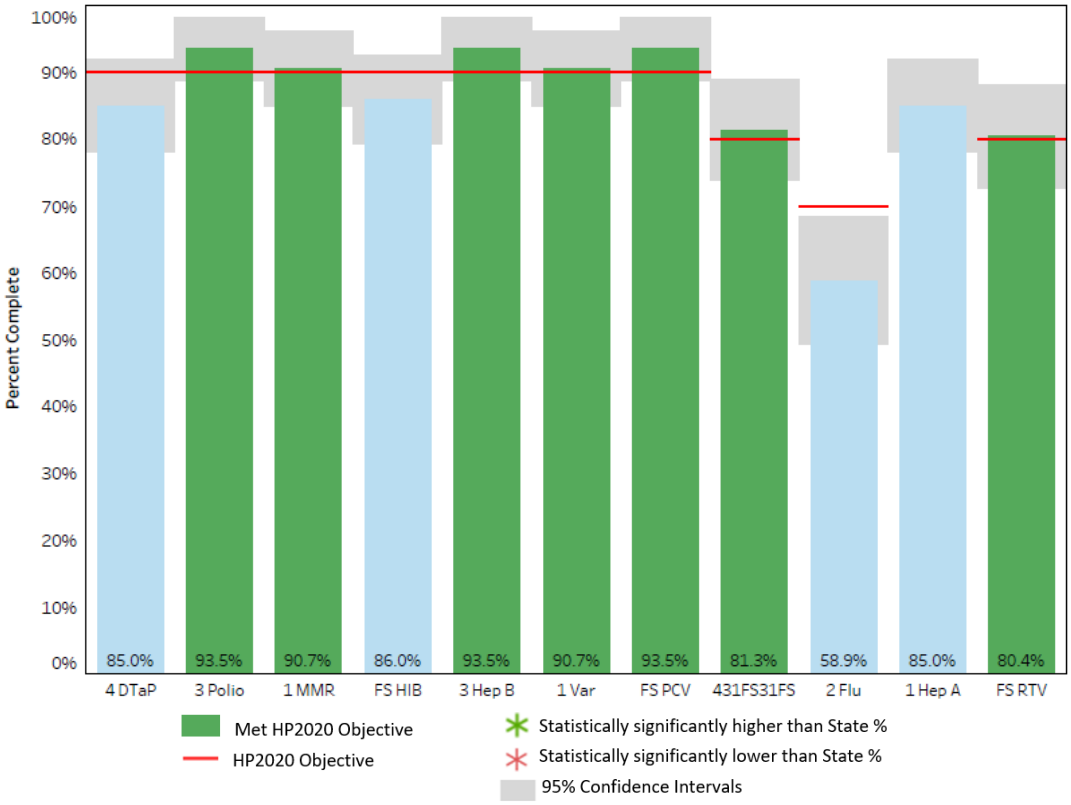
Percent of Children Complete in **Chattanooga-Hamilton Region (CHR)** by Vaccine (point estimates and 95% confidence intervals, n=115)



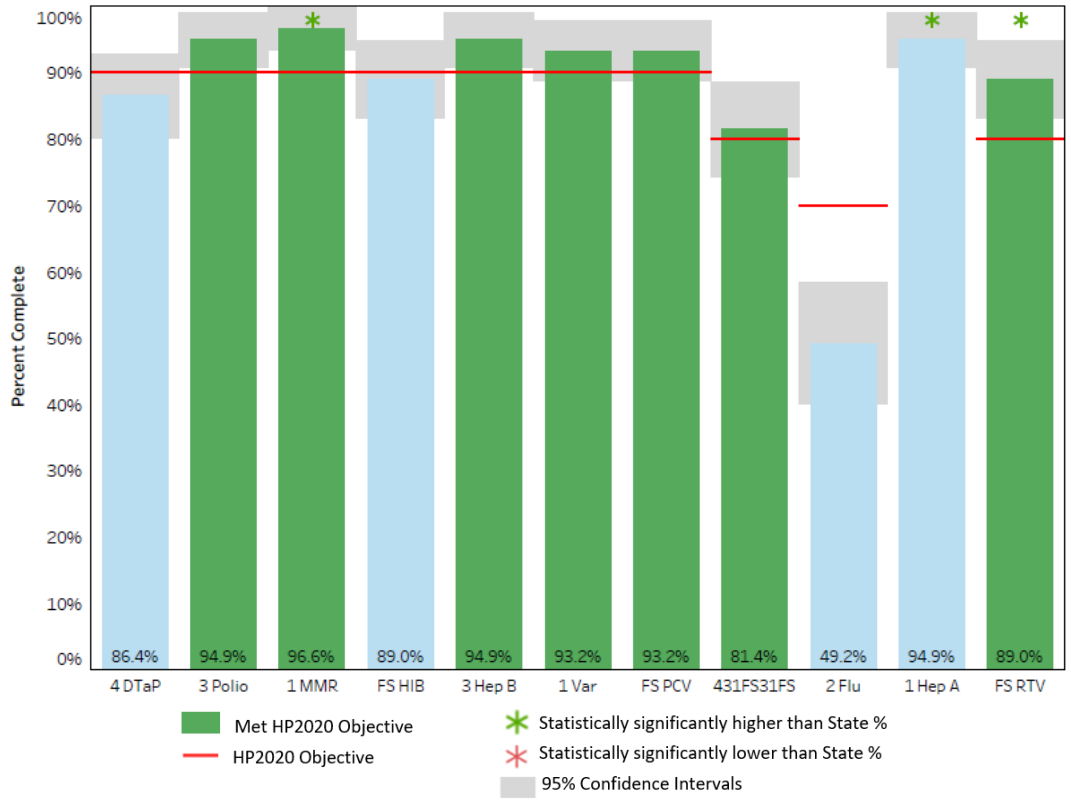
Percent of Children Complete in **East Tennessee Region (ETR)** by Vaccine (point estimates and 95% confidence intervals, n=114)



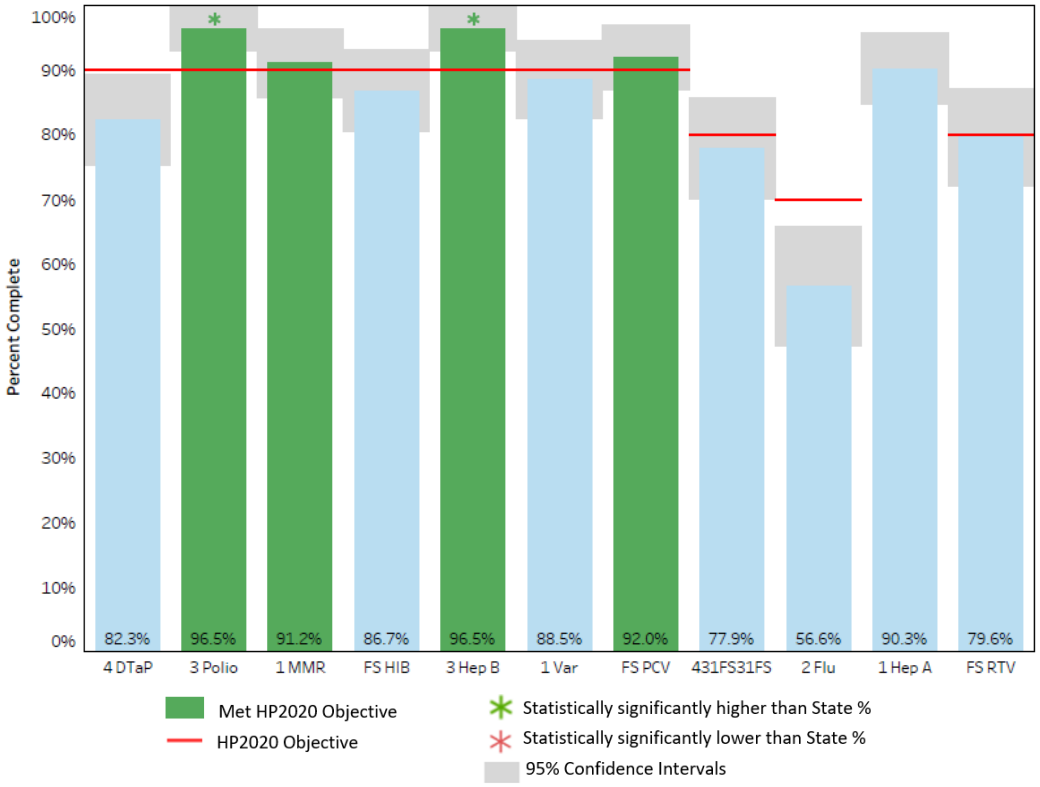
Percent of Children Complete in **Knoxville-Knox County Region (KKR)** by Vaccine (point estimates and 95% confidence intervals, n=107)



Percent of Children Complete in **Northeast Region (NER)** by Vaccine (point estimates and 95% confidence intervals, n=118)



Percent of Children Complete in **Sullivan County Region (SUL)** by Vaccine (point estimates and 95% confidence intervals, n=113)



Appendix 3

Data Tables for Selected Analyses

2019 Series (4:3:1:FS:3:1:FS) by Region

Region	Complete	%
Northeast TN	96/118	81.4
East TN	89/114	78.1
Southeast TN	89/111	80.2
Upper Cumberland	72/110	65.5
Mid-Cumberland	86/112	76.8
South Central	83/115	72.2
West TN	89/112	79.5
Memphis-Shelby County	88/114	77.2
Davidson County	84/113	74.3
Knoxville-Knox County	87/107	81.3
Chattanooga-Hamilton County	85/115	73.9
Madison County	88/114	77.2
Sullivan County	88/113	77.9
Total	1124/1468	76.6

2019 Series Complete (4:3:1:FS:3:1:FS) by Provider Type

Region	Public		Private		Public and Private	
	Complete	%	Complete	%	Complete	%
Northeast TN	4/6	66.7	81/98	82.7	11/13	84.6
East TN	2/3	66.7	79/92	85.9	8/10	80.0
Southeast TN	2/3	66.7	77/91	84.6	70/14	71.4
Upper Cumberland	2/3	66.7	61/84	72.6	9/20	45.0
Mid-Cumberland	0/0	-	73/89	82.0	13/16	81.3
South Central	0/1	0.0	67/80	83.8	16/21	76.2
West TN	10/15	66.7	60/67	89.6	17/24	70.8
Memphis-Shelby County	0/4	0	78/94	83.0	9/13	69.2
Davidson County	0/0	-	74/93	79.6	5/7	71.4
Knox County	2/2	100.0	78/93	86.9	7/8	87.5
Chattanooga-Hamilton County	0/1	0.0	81/100	81.0	3/7	42.9
Madison County	6/8	75.0	48/64	75.0	31/35	88.6
Sullivan County	3/5	60.0	76/93	81.7	9/12	75.0
Total	31/51	60.8	933/1138	82.0	148/200	74.0

2019 Series Complete (4:3:1:FS:3:1:FS) by Race

Region	White		Black		Other	
	Complete	%	Complete	%	Complete	%
Northeast TN	91/112	81.3	2/2	100.0	3/4	75.0
East TN	85/110	77.3	3/3	100.0	1/1	100.0
Southeast TN	87/108	80.6	2/3	66.7	0/0	-
Upper Cumberland	70/106	66.0	2/4	50.0	0/0	-
Mid-Cumberland	77/99	77.8	6/10	60.0	3/3	100.0
South Central	77/109	70.6	6/6	100.0	0.0	-
West TN	70/89	78.7	19/23	82.6	0/0	-
Memphis-Shelby County	34/40	85.0	52/72	72.2	2/2	100.0
Davidson County	54/70	77014	27/36	75.0	3/7	42.9
Knox County	76/95	80.0	7/8	87.5	4/4	100.0
Chattanooga-Hamilton County	75/93	80.7	9/17	52.9	1/5	20.0
Madison County	42/54	77.8	45/59	76.3	1/1	100.0
Sullivan County	85/109	78.0	½	50.0	2/2	100.0
Total	923/1194	77.3	181/245	73.3	20/29	67.0

2019 Series Complete (4:3:1:FS:3:1:FS) by Number of Older Siblings

Region	0 Siblings		1 Sibling		2+ Siblings	
	Complete	%	Complete	%	Complete	%
Northeast TN	45/50	90.0	29/41	70.7	22/27	81.5
East TN	42/48	87.5	26/36	72.2	21/30	70.0
Southeast TN	45/48	93.8	32/40	80.0	12/23	52.2
Upper Cumberland	25/35	71.4	26/46	56.5	21/29	72.4
Mid-Cumberland	44/50	88.0	25/36	69.4	17/26	65.4
South Central	42/47	89.4	26/33	78.8	15/35	42.9
West TN	37/43	86.1	30/36	83.3	22/33	66.7
Memphis-Shelby County	42/50	84.0	26/32	81.3	20/32	62.5
Davidson County	39/45	86.7	25/38	65.8	20/30	66.7
Knox County	40/43	93.0	31/39	79.5	16/25	64.0
Chattanooga-Hamilton County	33/39	84.6	31/44	70.4	21/32	65.6
Madison County	36/42	85.7	19/28	67.9	33/44	75.0
Sullivan County	29/33	87.9	36/44	81.8	23/36	63.9
Total	499/576	87.1	362/493	73.4	263/402	65.4

2019 Series Complete (4:3:1:FS:3:1:FS) by TennCare Enrollment

Region	Enrolled		Not Enrolled	
	Complete	%	Complete	%
Northeast TN	57/72	79.2	39/46	84.8
East TN	72/85	84.7	17/29	58.6
Southeast TN	57/69	82.6	32/42	76.2
Upper Cumberland	51/79	54.6	21/31	67.7
Mid-Cumberland	44/55	80.0	42/57	73.7
South Central	62/78	79.5	21/37	56.8
West TN	64/80	80.0	25/32	78.1
Memphis-Shelby County	63/83	75.9	25/31	80.7
Davidson County	55/69	79.7	29/44	65.9
Knox County	45/55	81.8	42/52	80.8
Chattanooga-Hamilton County	39/54	72.2	46/61	75.4
Madison County	70/90	77.8	18/24	75.0
Sullivan County	58/80	72.5	30/33	90.9
Total	737/949	77.7	387/519	74.6

Series Complete (4:3:1:FS:3:1:FS) by WIC Enrollment

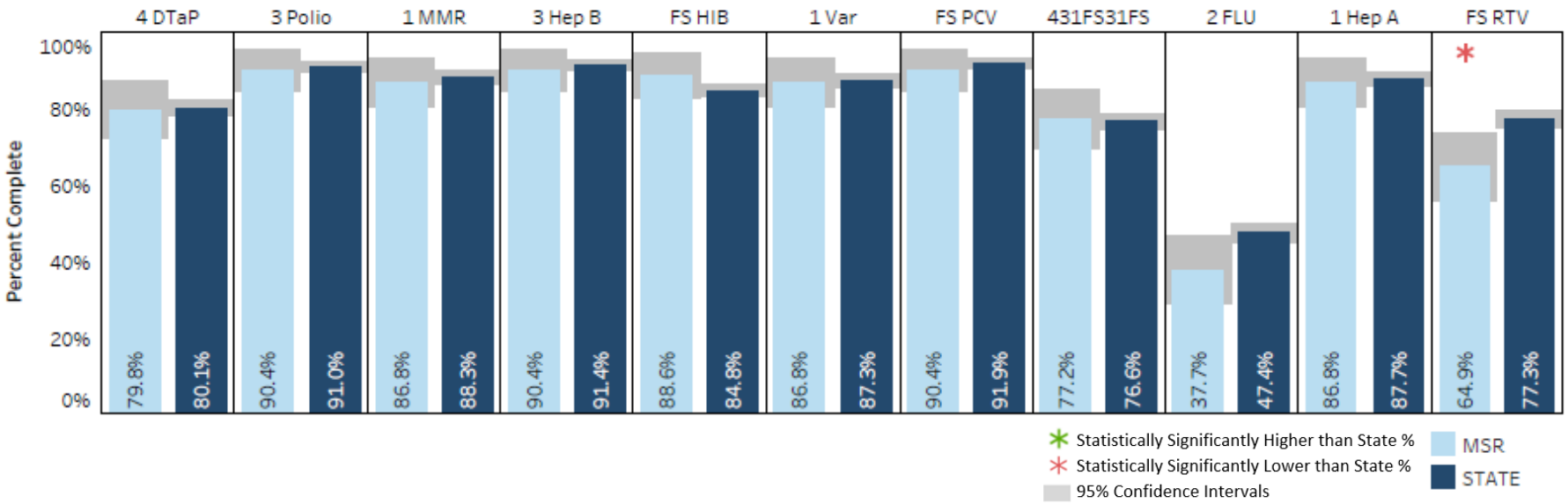
Region	Enrolled		Not Enrolled	
	Complete	%	Complete	%
Northeast TN	53/68	78.0	43/50	86.0
East TN	63/81	77.8	26/33	78.8
Southeast TN	53/67	79.1	36/44	81.8
Upper Cumberland	46/76	60.5	26/34	76.5
Mid-Cumberland	33/42	78.6	53/70	75.7
South Central	50/65	76.9	33/50	66.0
West TN	55/71	77.5	34/41	82.9
Memphis-Shelby County	61/78	78.2	27/36	75.0
Davidson County	45/57	79.0	39/56	69.6
Knox County	30/38	79.0	57/69	82.6
Chattanooga-Hamilton County	27/41	65.9	58/74	78.4
Madison County	25/35	71.4	63/79	79.8
Sullivan County	46/67	68.7	42/46	91.3
Total	625/830	75.3	499/638	78.2

Appendix 4

Regional One Page Summaries

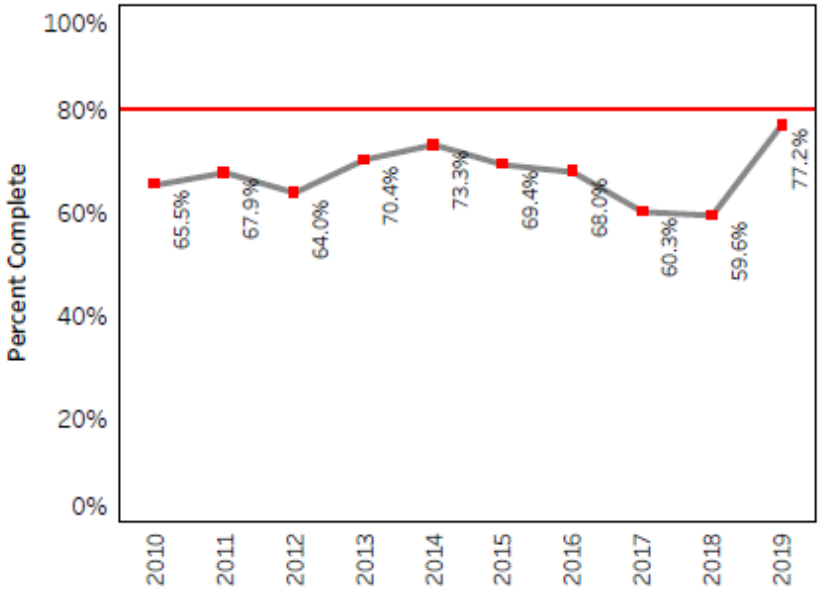
Memphis-Shelby Region
24-Month-Old Survey, 2019

Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



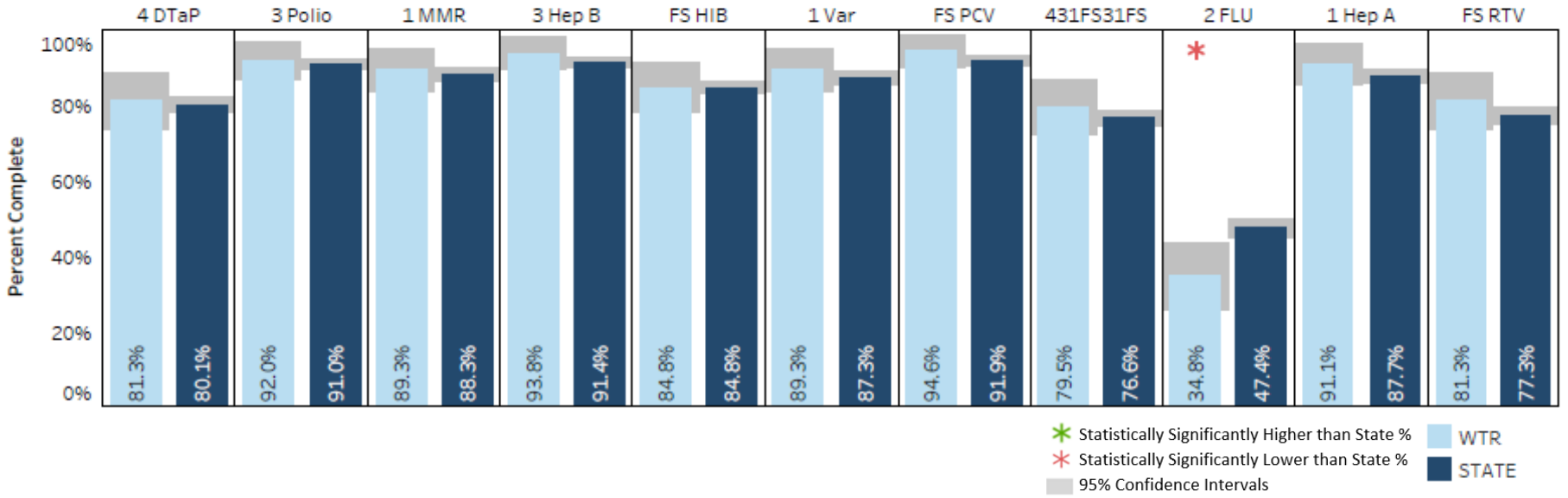
MSR Attainment of HP2020 Objective, by Vaccine, 2019

4:3:1:FS:3:1:FS Immunization Rate Trends, MSR, 2010-2019

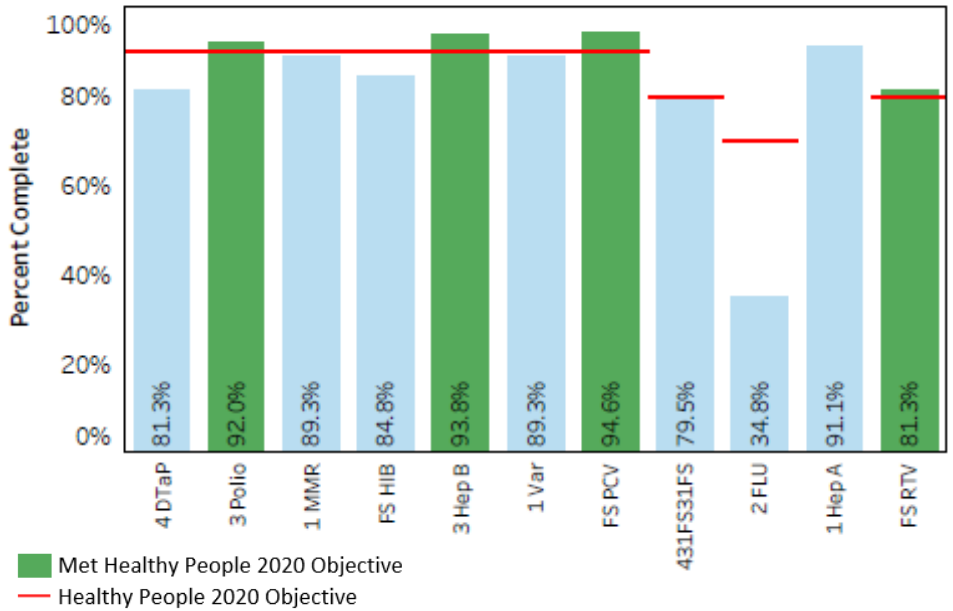


West Tennessee Region
24-Month-Old Survey, 2019

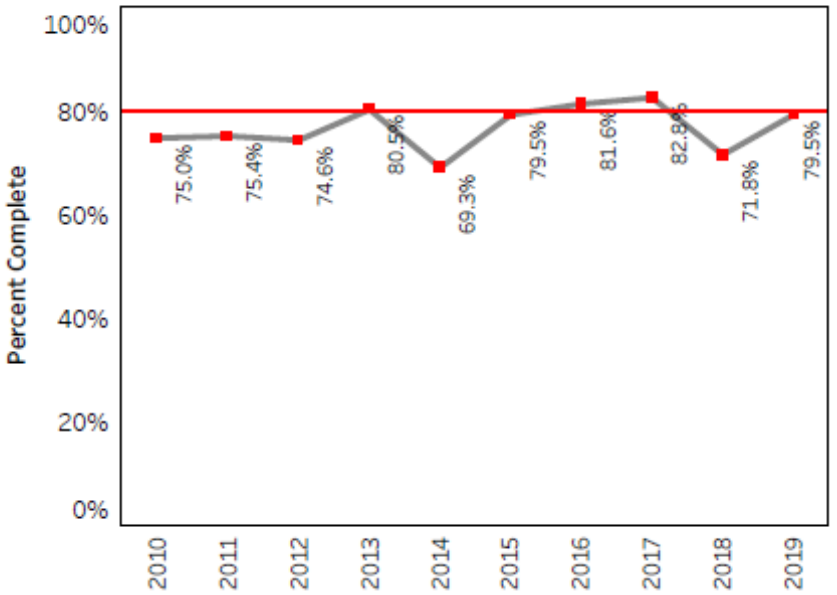
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



WTR Attainment of HP2020 Objective, by Vaccine, 2019

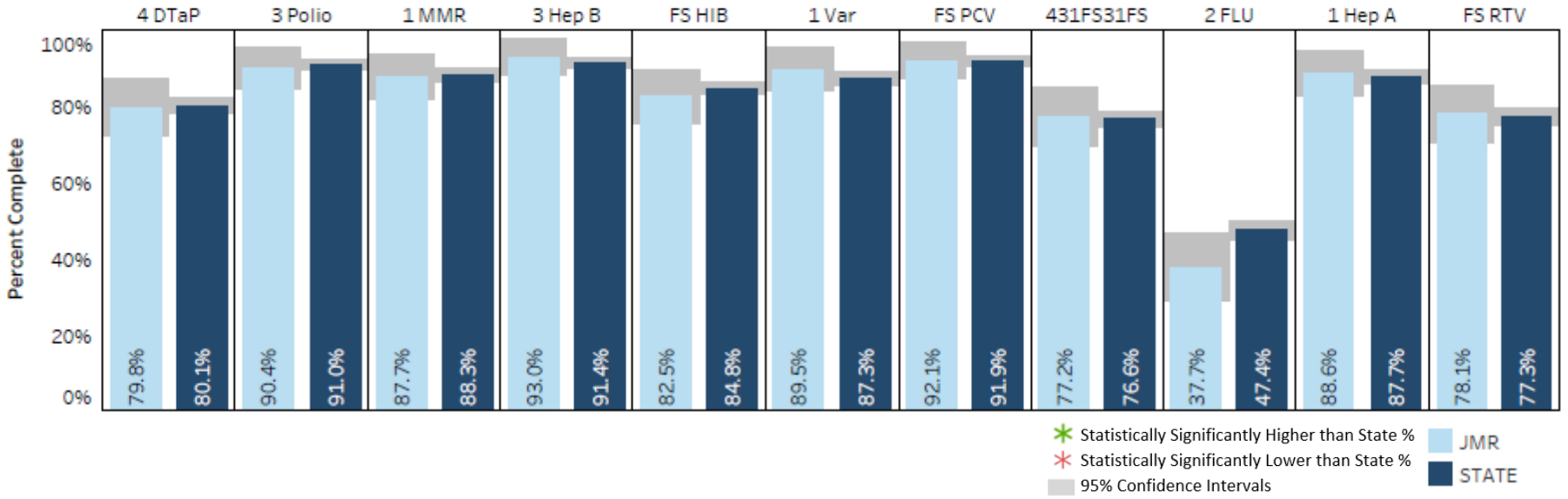


4:3:1:FS:3:1:FS Immunization Rate Trends, WTR, 2010-2019

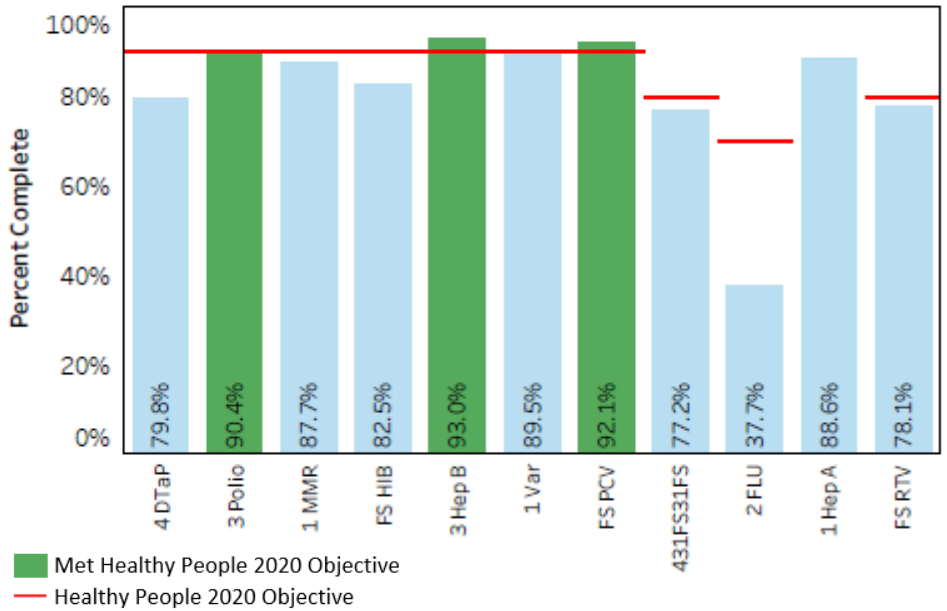


Jackson-Madison Region
24-Month-Old Survey, 2019

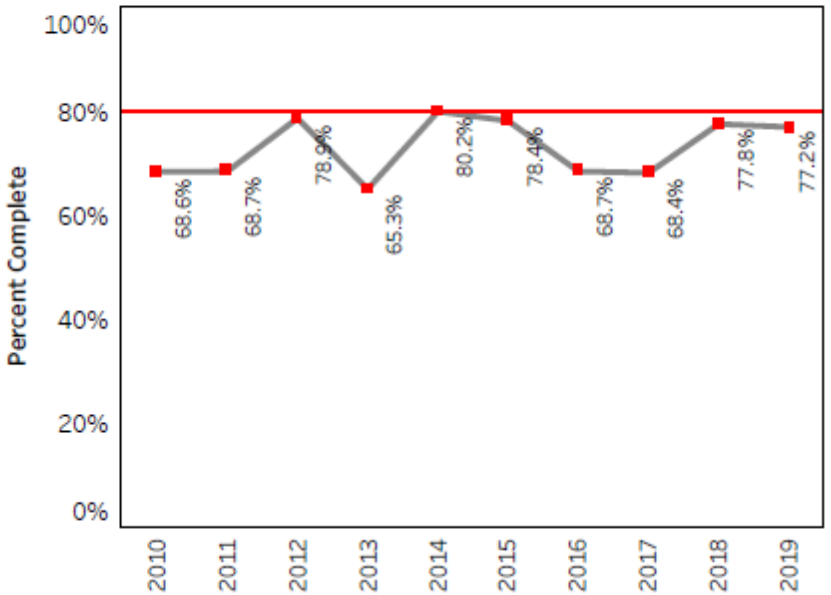
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



JMR Attainment of HP2020 Objective, by Vaccine, 2019

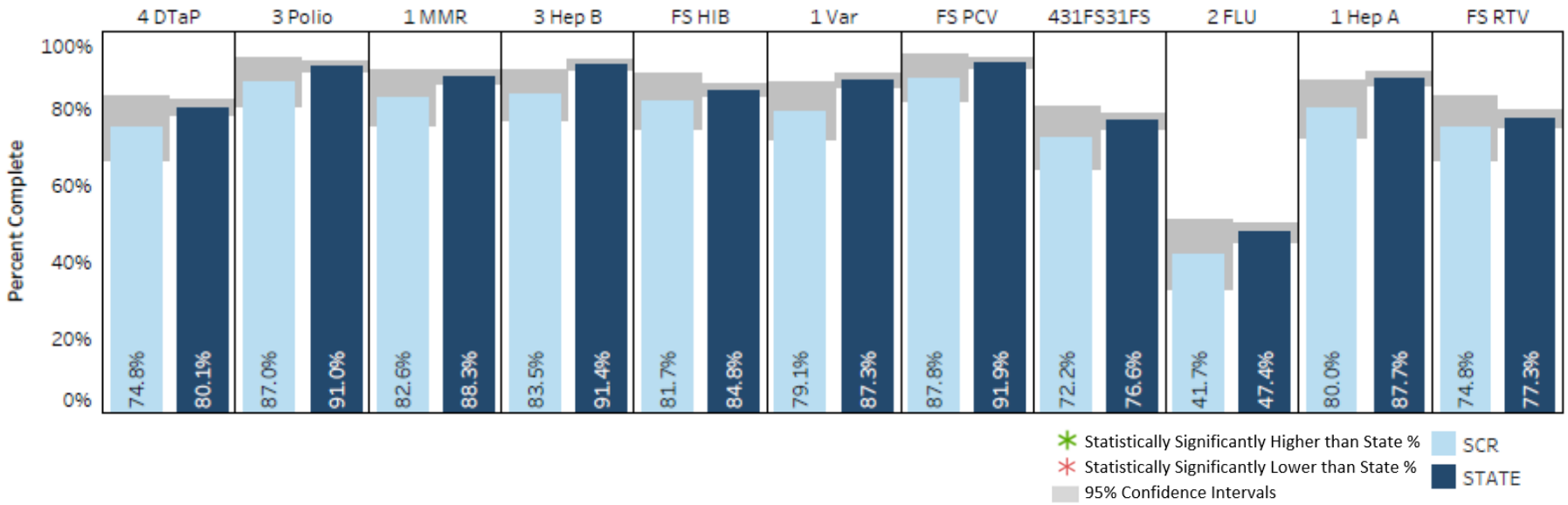


4:3:1:FS:3:1:FS Immunization Rate Trends, JMR, 2010-2019

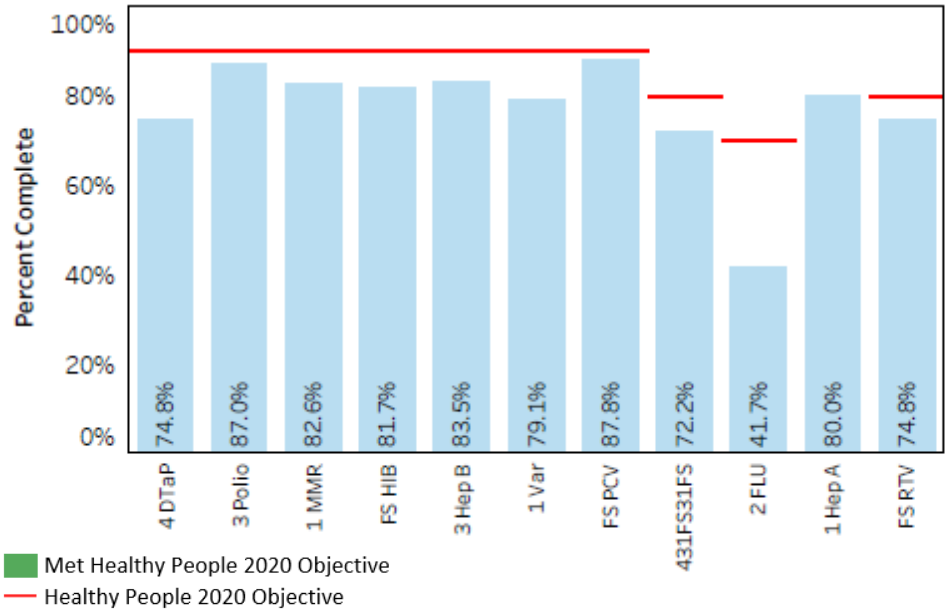


South Central Region
24-Month-Old Survey, 2019

Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



SCR Attainment of HP2020 Objective, by Vaccine, 2019



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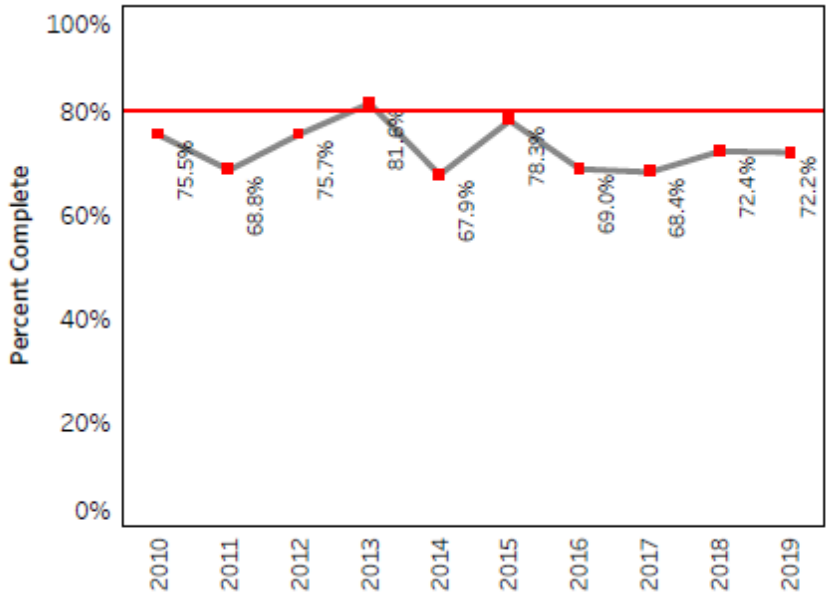
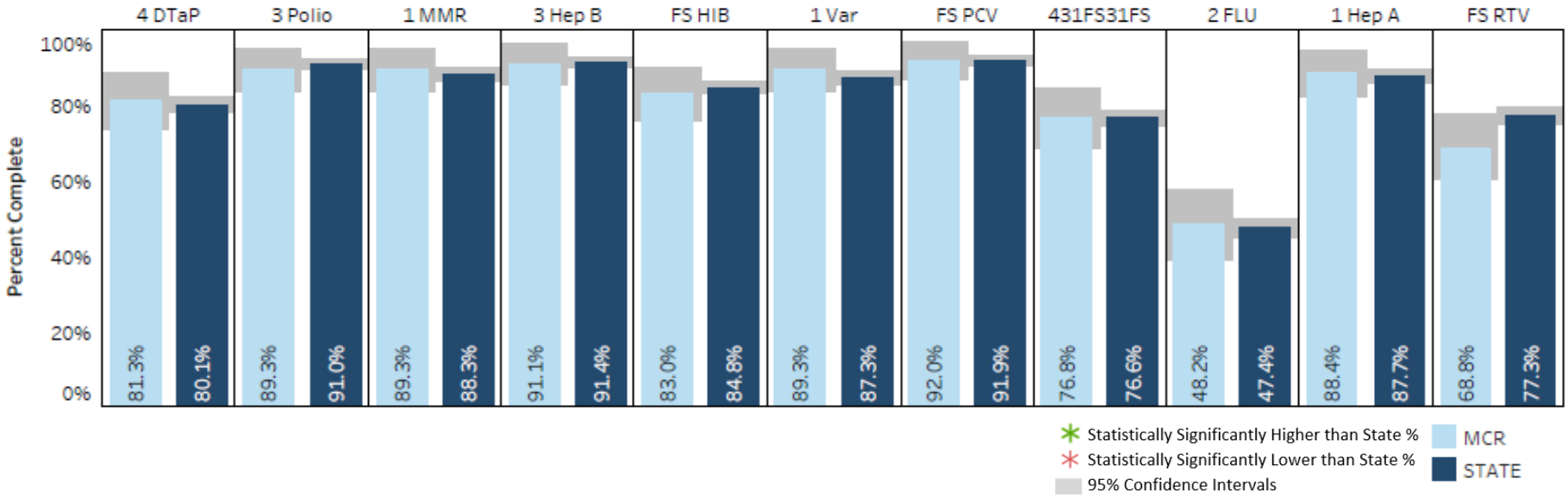
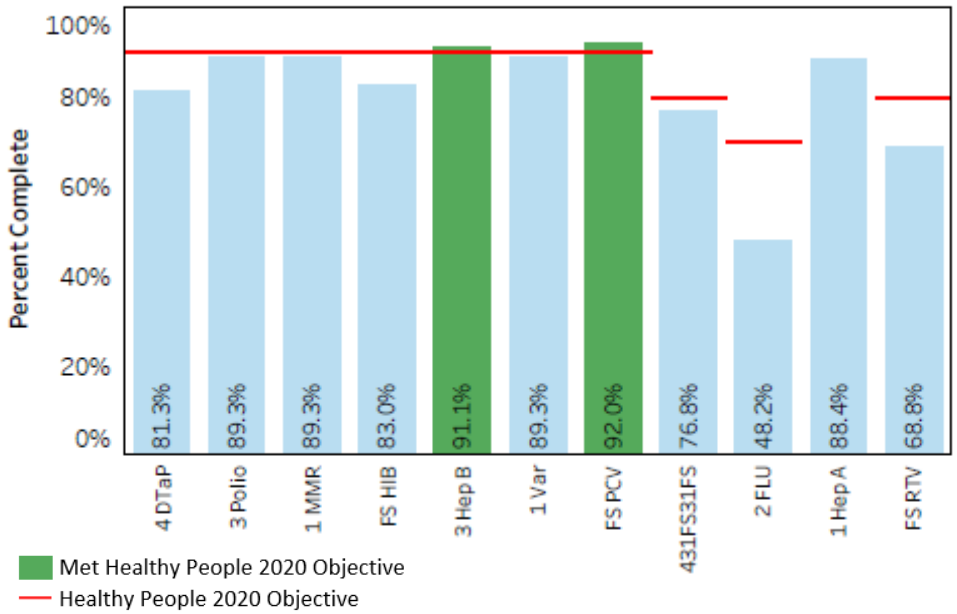


Mid-Cumberland Region
24-Month-Old Survey, 2019

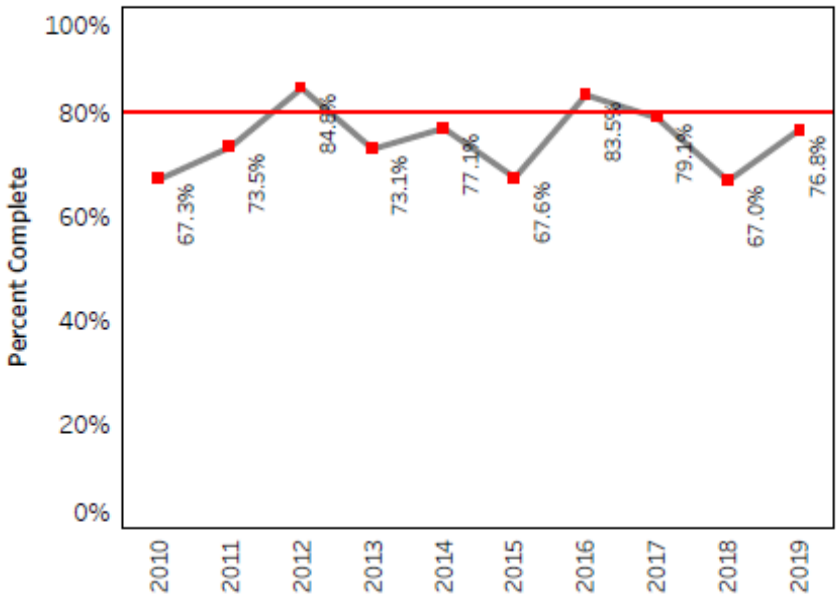
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



MCR Attainment of HP2020 Objective, by Vaccine, 2019

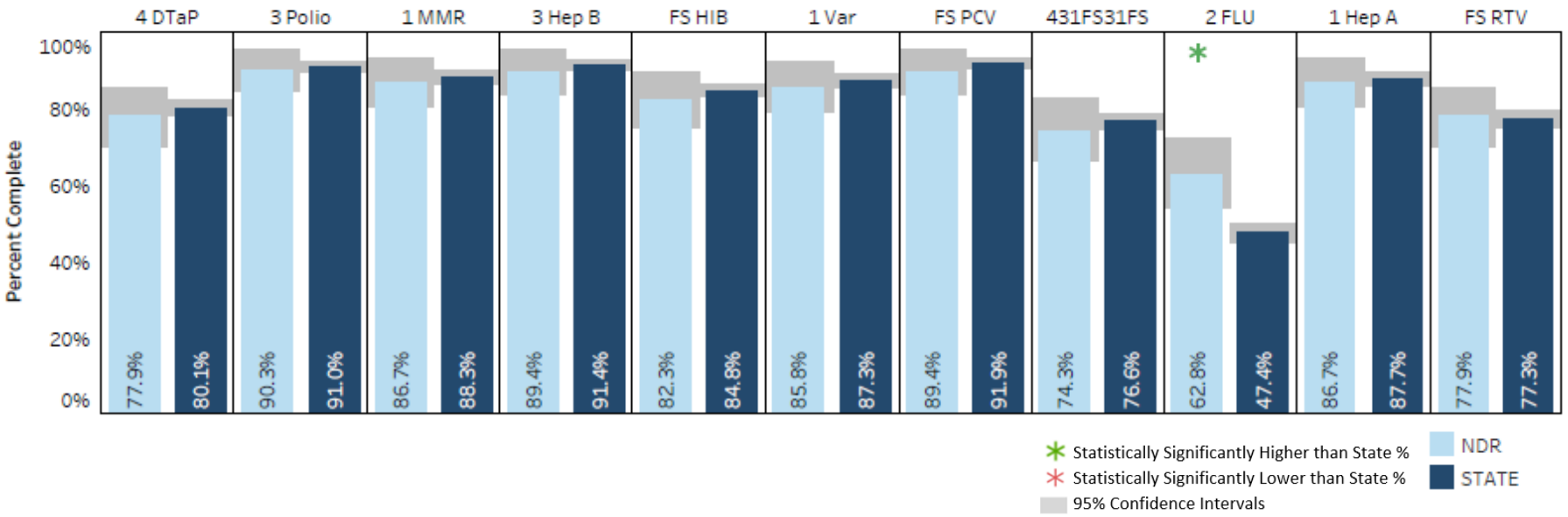


4:3:1:FS:3:1:FS Immunization Rate Trends, MCR, 2010-2019

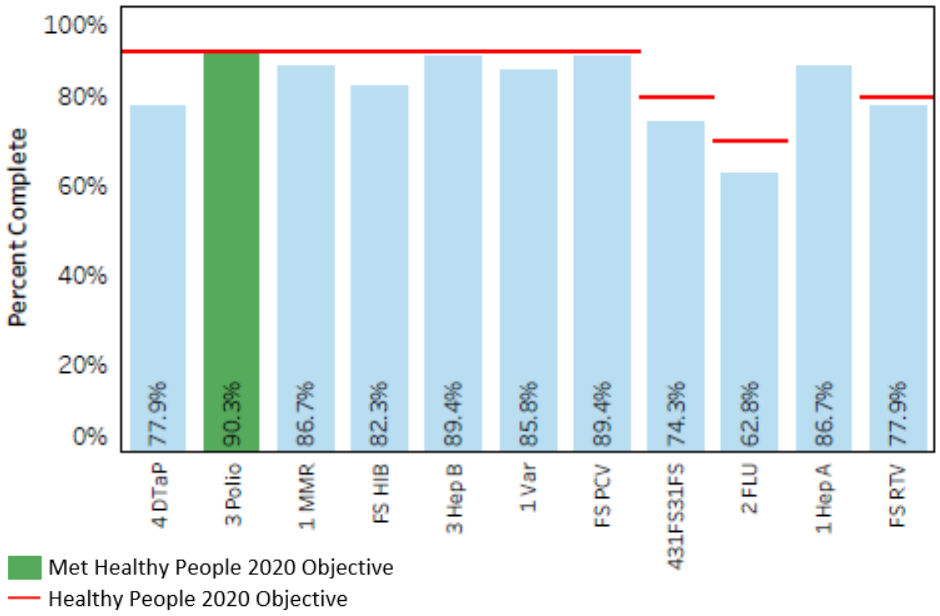


Nashville-Davidson Region
24-Month-Old Survey, 2019

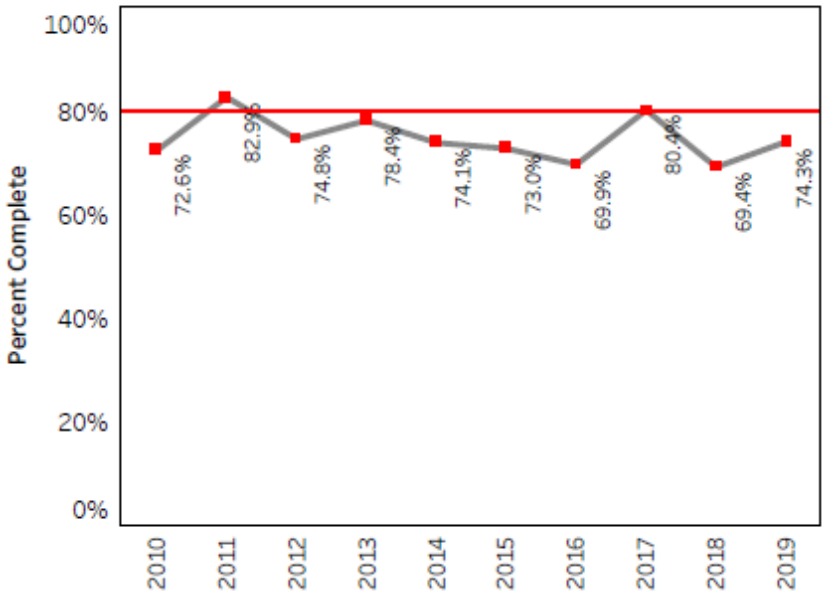
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



NDR Attainment of HP2020 Objective, by Vaccine, 2019

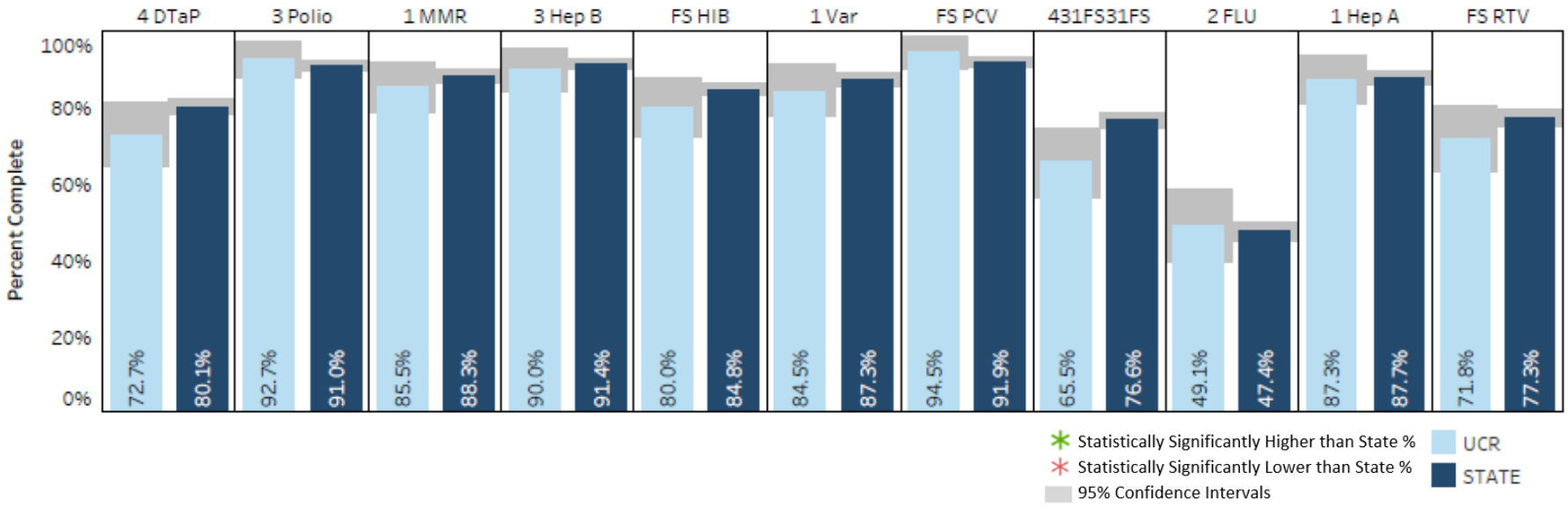


4:3:1:FS:3:1:FS Immunization Rate Trends, NDR, 2010-2019

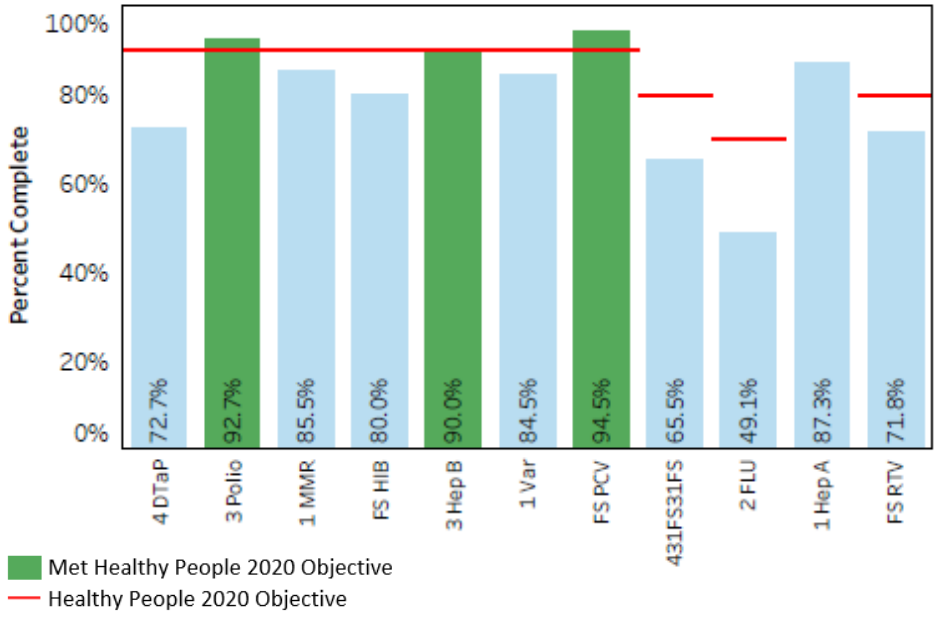


Upper-Cumberland Region
24-Month-Old Survey, 2019

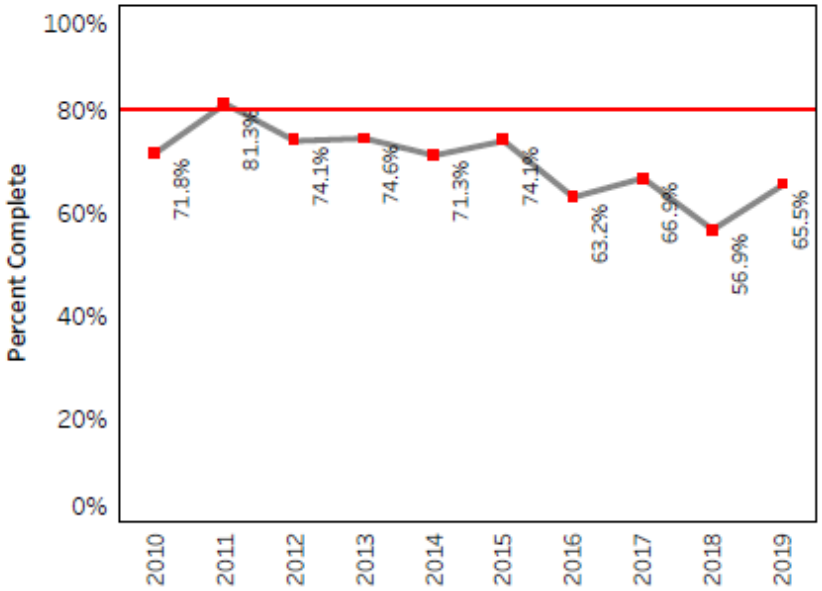
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



UCR Attainment of HP2020 Objective, by Vaccine, 2019



4:3:1:FS:3:1:FS Immunization Rate Trends, UCR, 2010-2019

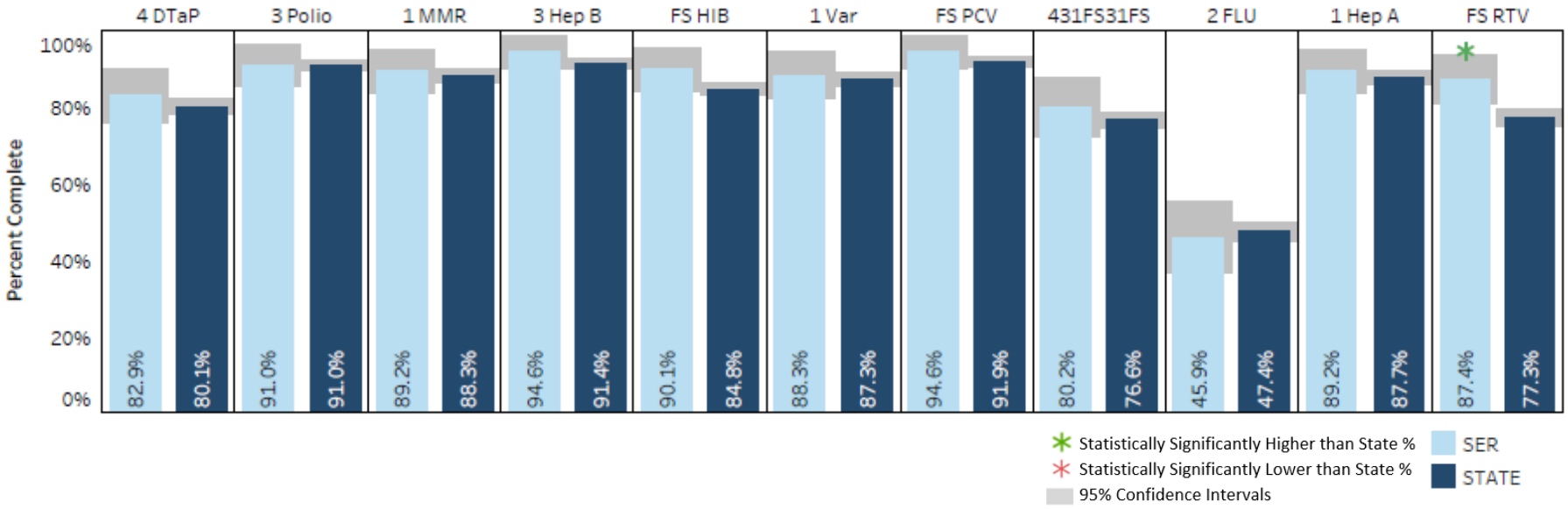


TN Department of Health

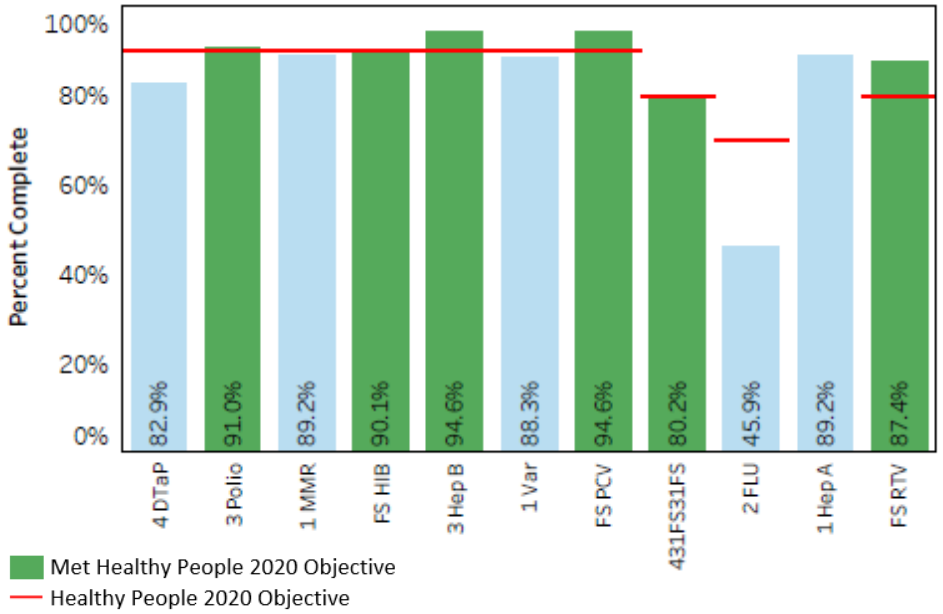
Southeast Region

24-Month-Old Survey, 2019

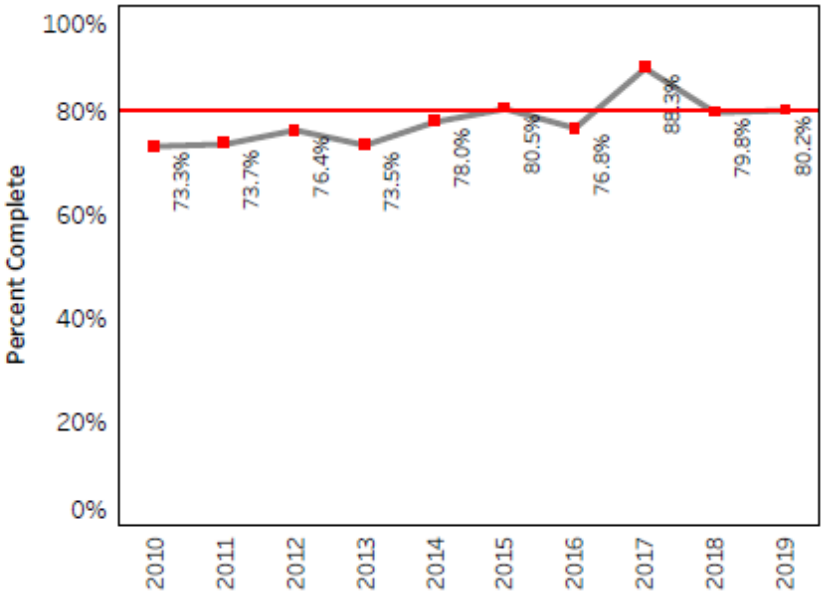
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



SER Attainment of HP2020 Objective, by Vaccine, 2019

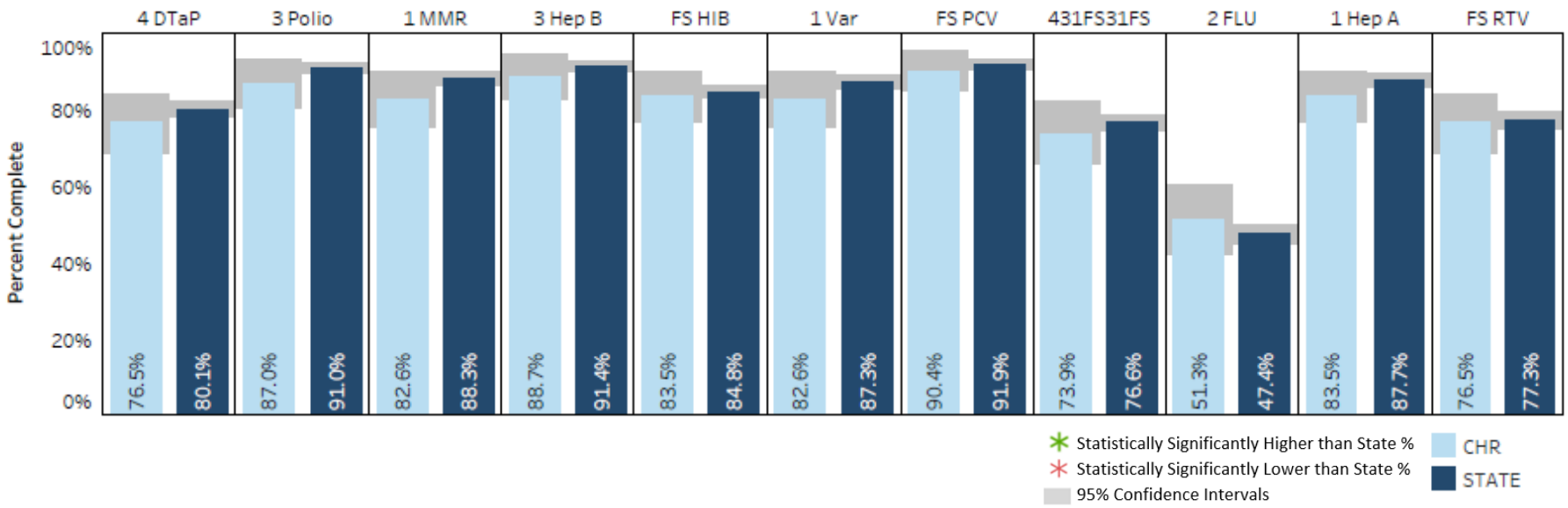


4:3:1:FS:3:1:FS Immunization Rate Trends, SER, 2010-2019

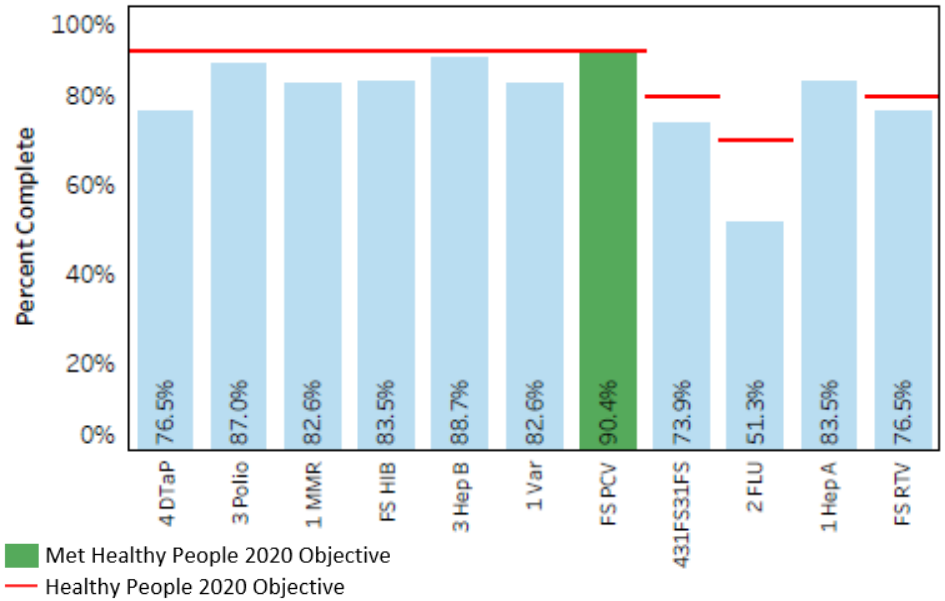


Chattanooga-Hamilton Region
24-Month-Old Survey, 2019

Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



CHR Attainment of HP2020 Objective, by Vaccine, 2019



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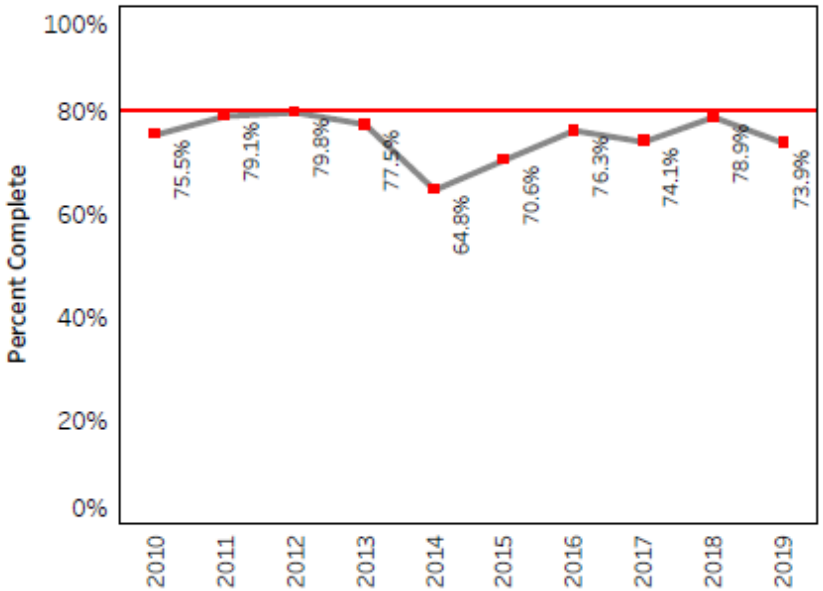
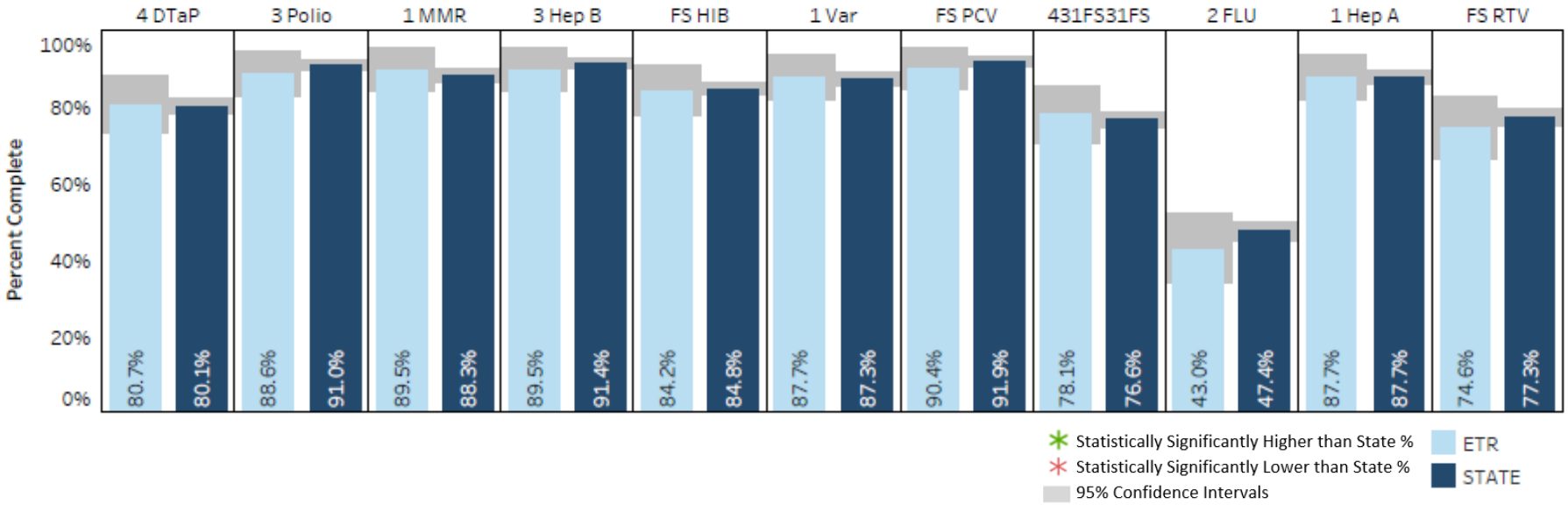


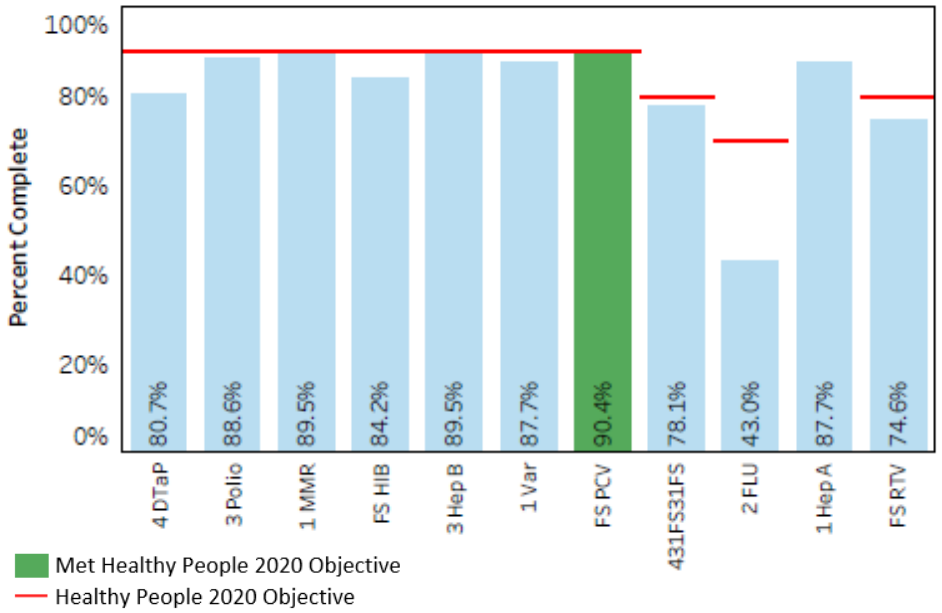
TN Department of Health

East Tennessee Region
24-Month-Old Survey, 2019

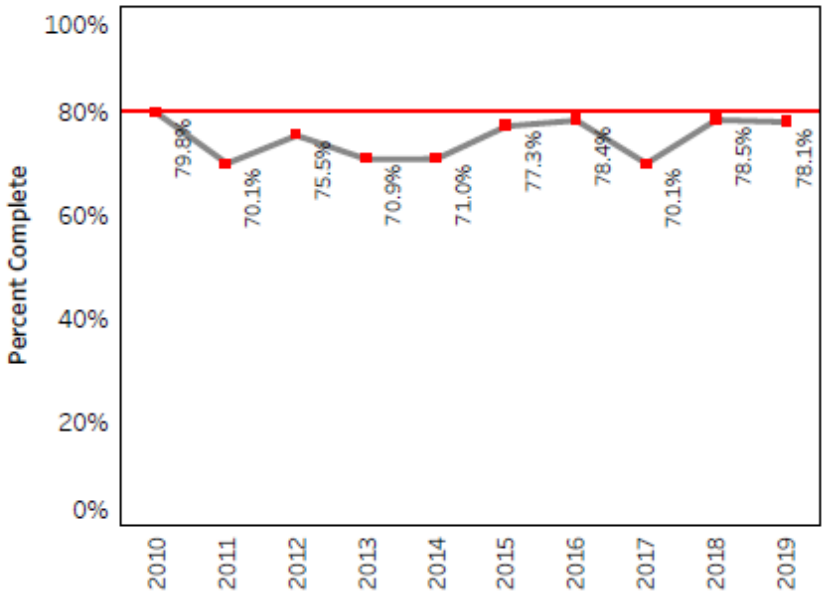
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



ETR Attainment of HP2020 Objective, by Vaccine, 2019



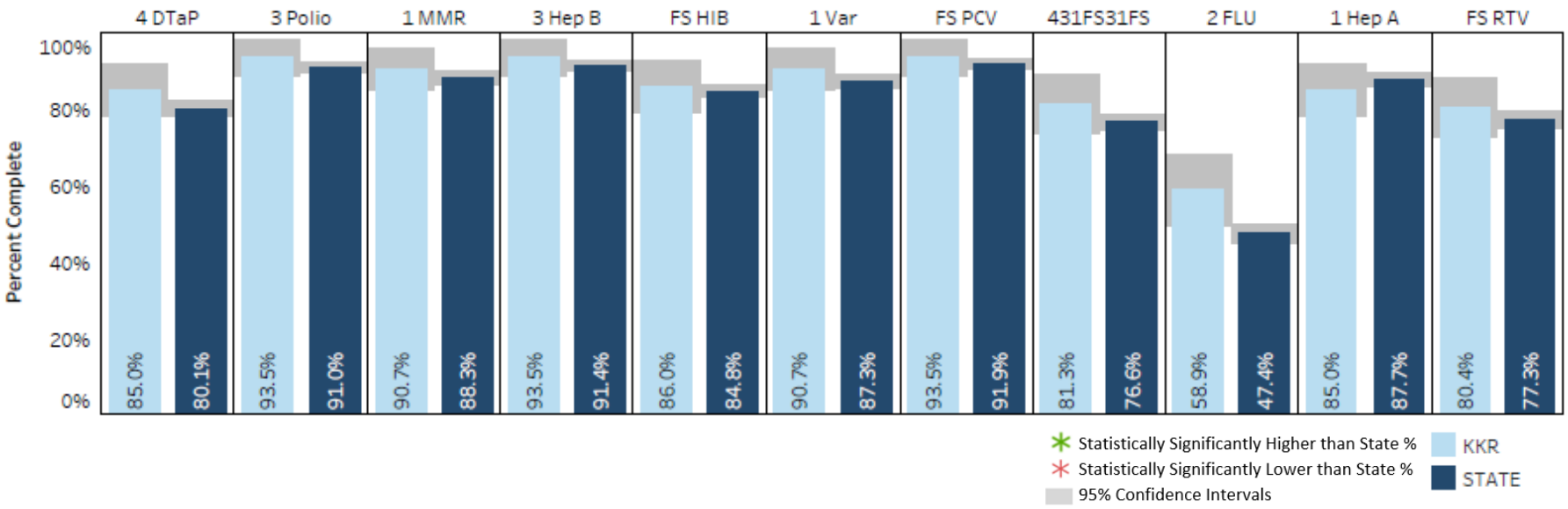
4:3:1:FS:3:1:FS Immunization Rate Trends, ETR, 2010-2019



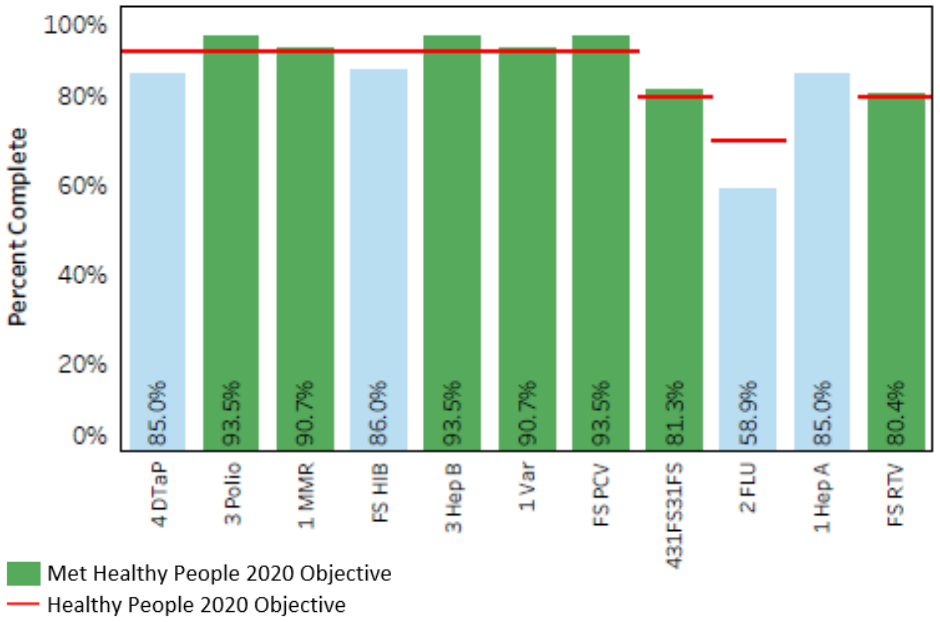
Knoxville-Knox County Region

24-Month-Old Survey, 2019

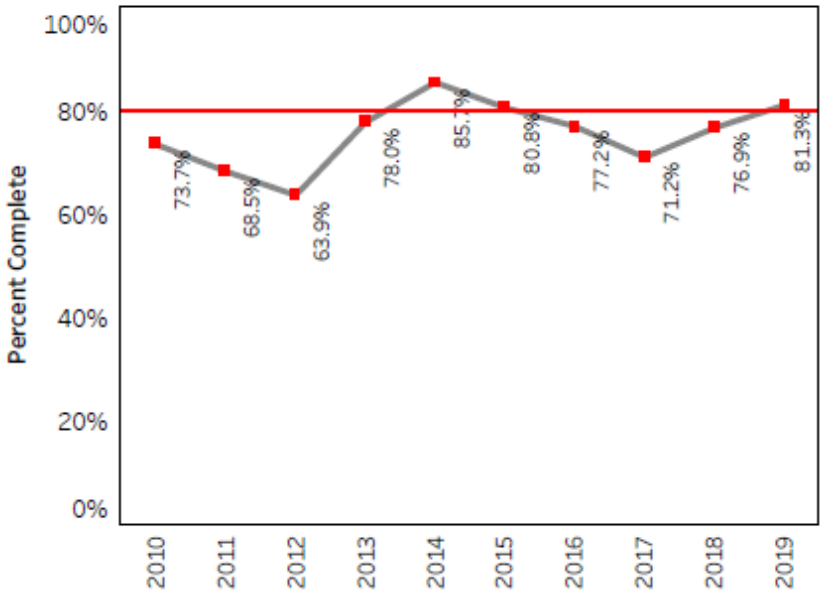
Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



KKR Attainment of HP2020 Objective, by Vaccine, 2019

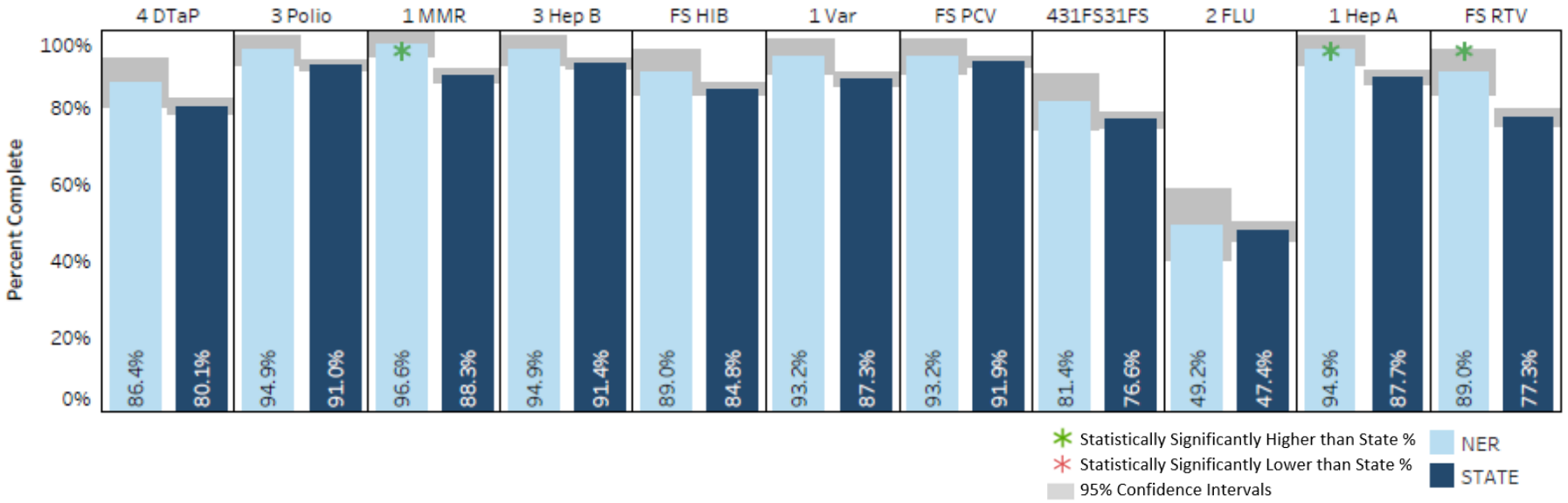


4:3:1:FS:3:1:FS Immunization Rate Trends, KKR, 2010-2019

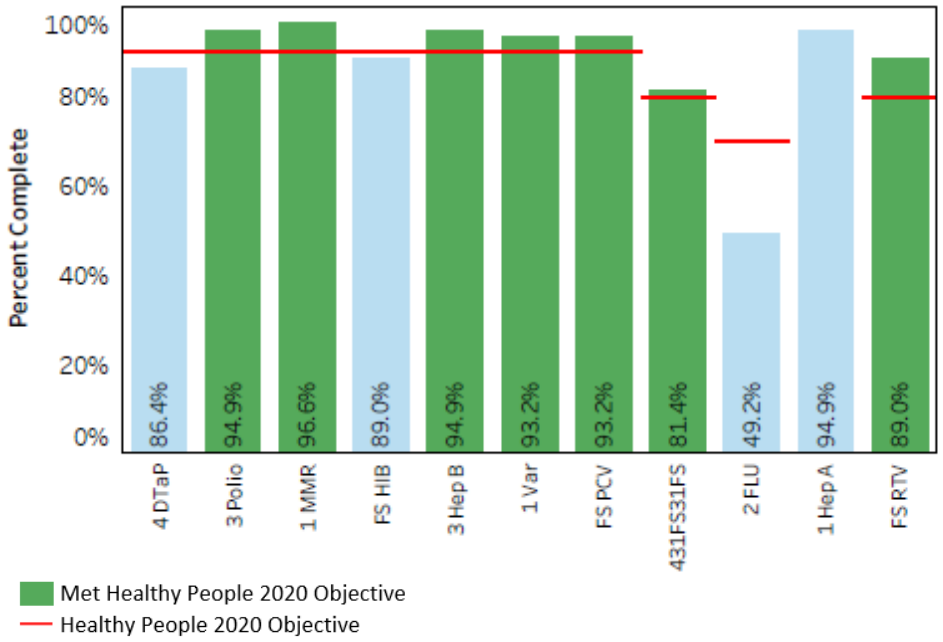


Northeast Region
24-Month-Old Survey, 2019

Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



NER Attainment of HP2020 Objective, by Vaccine, 2019



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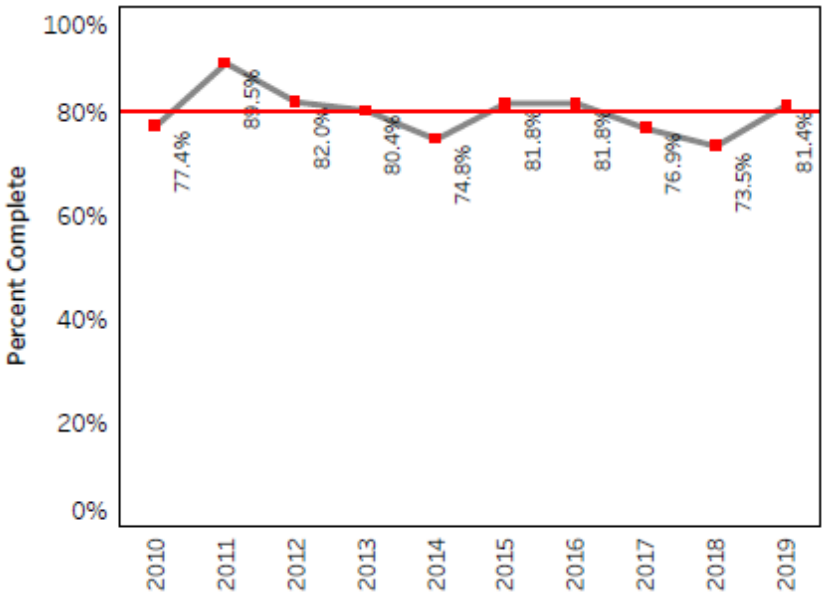
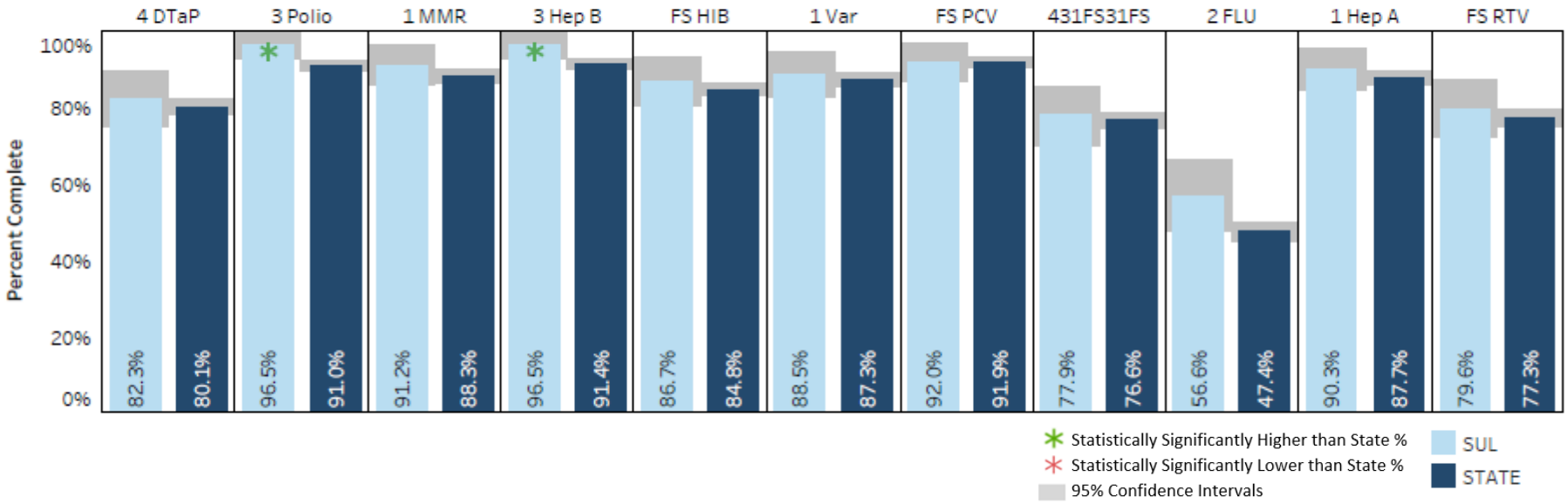


Sullivan Region

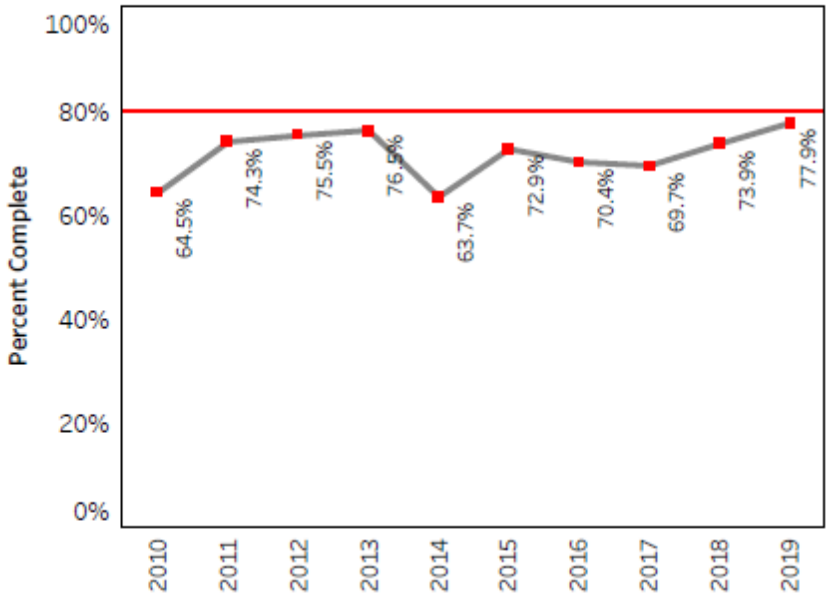
24-Month-Old Survey, 2019

Comparison of Regional and State Vaccination Rates, by Vaccine, 2019



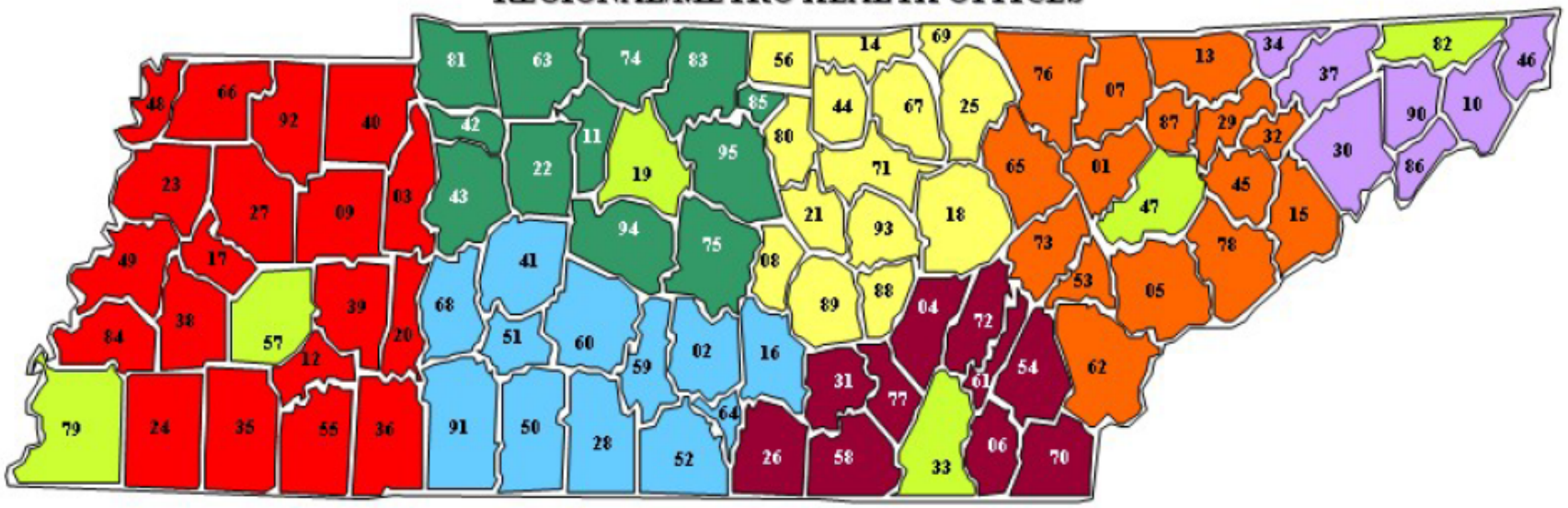
SUL Attainment of HP2020 Objective, by Vaccine, 2019

4:3:1:FS:3:1:FS Immunization Rate Trends, SUL, 2010-2019



Appendix 5

TENNESSEE DEPARTMENT OF HEALTH
REGIONAL/METRO HEALTH OFFICES



West		Mid Cumberland		South Central		Southeast		Upper Cumberland		East		North East	
#	County	#	County	#	County	#	County	#	County	#	County	#	County
03	Benton	11	Cheatham	02	Bedford	04	Bledsoe	08	Cannon	01	Anderson	10	Carter
09	Carroll	22	Dickson	16	Coffee	06	Bradley	14	Clay	05	Blount	30	Greene
12	Chester	42	Houston	28	Giles	26	Franklin	18	Cumberland	07	Campbell	34	Hancock
17	Crockett	43	Humphreys	41	Hickman	31	Grundy	21	DeKalb	13	Claiborne	37	Hawkins
20	Decatur	63	Montgomery	50	Lawrence	54	McMinn	25	Fentress	15	Cocke	46	Johnson
23	Dyer	74	Robertson	51	Lewis	58	Marion	44	Jackson	29	Grainger	86	Unicoi
24	Fayette	75	Rutherford	52	Lincoln	61	Meigs	56	Macon	32	Hamblen	90	Washington
27	Gibson	81	Stewart	59	Marshall	70	Polk	67	Overton	45	Jefferson		
35	Hardeman	83	Sumner	60	Maury	72	Rhea	69	Pickett	53	Loudon		
36	Hardin	85	Trousdale	64	Moore	77	Sequatchie	71	Putnam	62	Monroe		METROS
38	Haywood	94	Williamson	68	Perry			80	Smith	65	Morgan	#	County
39	Henderson	95	Wilson	91	Wayne			88	Van Buren	73	Roane	19	Davidson
40	Henry							89	Warren	76	Scott	33	Hamilton
48	Lake							93	White	78	Sevier	47	Knox
49	Lauderdale									87	Union	57	Madison
55	McNairy											79	Shelby
66	Obion											82	Sullivan
84	Tipton												
92	Weakley												