TREND ANALYSIS OF CONFIRMED CASES OF STREPTOCOCCUS PNEUMONIAE FROM 2014 TO 2017 IN SELECT MUNICIPAL KANSAS COUNTIES

by

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Abstract

Streptococcus pneumoniae, also known as pneumococcal disease, has been an extortionary burden on public health for well over a century and continues to affect high-risk groups,which includes the unvaccinated, children under the age of two, adults age sixty-five and older, and individuals with weakened immune systems or a history of smoking and/or asthma.

Since 2015, Sedgwick County along with other select Kansas Counties have had a substantial increase in the number of *S. pneumoniae* cases. As a result, the county decided to uncover the possible cause(s) of the increased prevalence, if any of the population's demographic might have been disproportionately affected and what the efficacy is of the available vaccines.

After receiving the patient's information from the included counties, the data was arranged into frequency and rate tables, followed by chi-square tables, to compare population estimates of the demographics for each county in Kansas (KS) to the study populations. The study populations were found to be representative of each of the Counties and KS overall. Calculations were then performed using R to compare the odds of mortality between the unvaccinated and vaccinated, the type of vaccine received and the county in which they reside. Lastly, a model containing the variables: age, race/ethnicity and county of residence was run to approximate a rate of diseases using the included variables. Unfortunately, due to a low study population, most of the findings were not significant. However, County of residence, year of initial diagnosis, vaccine type received, number of days hospitalized post-infection, and underlying medical conditions were found to be the best predictor of the patient's odds of succumbing to *S. pneumoniae*.

Keywords: Streptococcus pneumoniae, S. pneumoniae, Pneumococcus, Pneumococcal, Pneumonia, Epidemiology, Kansas, Sedgwick County, Public Health, Health Department, Division of Health

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Preface

My field experience and capstone project were completed at the Sedgwick County Division of Health (SCDOH) in Wichita, Kansas. My internship preceptor was Ms. Hervey, MPH, the Epidemiology Program Manager at SCDOH. This field experience included 221 on-site hours and was conducted between July 2, 2018, and March 12, 2019.

The purpose of this project was to compile a database of Sedgwick, Shawnee, and Johnson County's' invasive *S. pneumoniae* cases, along with vaccination histories and disease investigation data for all reported cases from 2014 through 2017 (four years). This database was then used to analyze frequencies and rates across these counties and years that were included in the dataset. Statistical models were used to determine possible correlations between disease investigation fields (i.e. vaccination status, clinical information, demographic, geographic, etc.) and disease morbidity and mortality. The compiled data would then be used to determine why select Public Health Departments across Kansas have been experiencing increases in the number of *S. pneumoniae* cases.

The mission statement of Sedgwick County Division of Health (SCDOH) is "to improve the health of Sedgwick County residents by preventing disease, promoting wellness and protecting the public from health threats." To uphold this mission, SCDOH has set three strategic goals for 2018: "Investigate and control communicable diseases, prevent communicable disease through immunizations and prepare for public health emergencies. Promote healthy birth outcomes. Lead collaboration among community health clinics and provide preventive health services." It is my sincere hope that this paper and the included data will assist Sedgwick County, as well as the other counties that participated in the completion of this project, in achieving their goals and decrease the total burden of *S. pneumoniae*-related diseases.

Chapter 1 – Introduction (Exposition)

From the late 1800s through most of the 1900s pneumonia and influenza, being listed as a single category, have continuously been ranked as one of the leading causes of death among citizens of the United States (US) and have consistently been the leading cause of death from infectious diseases through this same span of time [1]. Unfortunately, despite advancements in medicine and vaccines, pneumonia and influenza remain a common cause of death, being listed as the eighth leading cause of death in the US in 2016, with an estimated 51,537 individuals succumbing to these diseases [2]. Even though influenza does make up a significant portion of these deaths, the contributions from pneumonia should not be ignored. The leading cause of bacterial pneumonia is *Streptococcus pneumoniae,* also known as pneumococcal disease. An estimated 900,000 Americans are affected every year by pneumococcal pneumonia [3,4]. This alone is enough to make *S. pneumoniae* a threat to public health.

Discovery and Characterization

S. pneumoniae was first isolated in 1881 independently and simultaneously by Louis Pasteur [5,6] in France and U.S. Army physician, George Sternberg, [7,8] at Fort Mason, San Francisco, California. Both microbiologists roughly described "lancet-shaped pairs of coccoid bacteria" that were isolated from rabbits' blood that had previously been injected with human saliva. Pasteur had used saliva from a child that had died of a rabies infection, while Dr. Sternberg used his own saliva. As a result of this discovery, each researcher named the bacteria, with Pasteur naming it "*Microbe septicemique du salive"* [6] and Sternberg naming it *"Micrococcus pasteri."* [9] Prior to 1881, there had been some publications identifying elongated diplococci bacteria; however, there had been no records of experimentation that demonstrated the pathogenic potential of the bacteria in animal or human models.

Later in the same decade, *S. pneumoniae* was identified to have multiple forms of pathogenesis, as it played a significant role in individuals that had developed pneumonia [10-13], meningitis (inflammation of the meninges) [14] and otitis media (infection of the middle ear) [15]. These discoveries were a result of the development of the Gram's Stain by Christian Gram [16], a Danish bacteriologist who was conducting experiments in Carl Friedländer's laboratory. Friedländer [17] then proceeded to uses the Grams stain to examine sections of lung tissues of patients who had died as a result of pneumonia. Through these experiments, Friedländer was able to distinguish between two very different kinds of bacterial infections that cause pneumonia; the first, *S. pnuemoniae* stained deep purple, as a result of the bacteria retaining the primary dye aniline-gentian, also known as crystal violet. Crystal violet later become known as Gram-positive. The second bacteria Friedländer identified was bacillus (rod-shaped) and did not retain crystal violet, which caused it to appear pink in color (Gram-negative). The Gram-negative bacteria was later identified as *Klebsiella pneumoniae* [18], sometimes referred to as Friedländer's Bacillus. Five years after its discovery, in 1886, German physician Julius Albert Fraenkel, [19] coined the term "*pneumococcus"* to describe the Gram-positive bacteria, one of the causative agents of bacterial pneumonia.

In 1891, G. Klemperer and F. Klemperer [20, 21] found that after injecting rabbits with heat-killed pneumococci bacteria or with filtrates of broth cultures, the injected animal became immune to subsequent reintroductions of bacteria cells from the same clinical isolate. Furthermore, they found that the serum from animals that had previously been inoculated [20, 21], such as described previously, could be used to protect other rabbits that had not been exposed to pneumococcal infections.

These experiments were followed up by B. Issaeff in 1893 [22], who was able to demonstrate that the protection from the serum was not bactericidal, but rather promoted the

phagocytosis of the bacterial cells by the immune system. At the turn of the 20th century, Friedrich Neufeld [23] showed that aggregation and swelling of the external capsule of bacterial cells could be observed with a microscope when pneumococcal cells were mixed with the serum from previously inoculated animals. In 1904, Neufeld worked with W. Rimpau [24] to resolve the discrepancy between humoral and cellular immunity, by successfully demonstrating that it was the pre-exposure to pneumococcal cells, not the exposure of immune cells to the serum of an immunized animal that led to increased phagocytosis. These realizations eventually allowed scientist to differentiate between strains of bacteria of the same species by determining their aggregation when exposed to different pneumococcal antiserums [25,26]. This differentiation of these strains became known as serotyping and would in turn leading to the identification of more than 80 serotypes of *S. pneumoniae* by the end of 1940 [27].

In 1917, *S. pneumoniae's* capsular envelope was first identified by Alphonse Dochez and Oswald Avery [28], when they discovered a soluble substance in the serum and urine of individuals diagnosed with lobar pneumonia. These capsular envelops were also found in the blood of animals that had been experimentally infected with *S. pneumoniae*. Isolates of this substance precipitated when exposed to *S. pneumoniae* specific antiserum. Later, Avery and Michael Heidelberger [29] identified this substance as consisting mainly of complex carbohydrates, known as polysaccharides. Heidelberger [30] concluded that the polysaccharide cellular envelope was responsible for each strain's serological reactivity. It took an additional nine years before Lloyd Felton and Howard Baily [31] developed a process of isolating the polysaccharide envelope from the rest of the cell, which led them to discover that the capsule was the subcellular component responsible for inducing immunity in inoculated individuals.

In 1931, two papers, authored by Rene Dubos and Oswald Avery [32, 33], were published in the *Journal of Experimental Medicine* and successfully demonstrated that the

polysaccharide capsule contributed significantly to the pathogenicity of *S. pneumoniae*. They first identified chemical enzymes that were capable of decomposing the polysaccharide capsule of serotype 3 *S. pneumoniae* [32]. Avery and Dudos then demonstrated that these enzymes could be used to protect mice from diseases after receiving a lethal injection of serotype 3 *S. pneumoniae* [33]. This experiment was replicated three years later by Thomas Francis, Jr., et al. [34] with the enzyme displaying similar protective results in Java monkeys. This research, in combination with early work, led to the development of pneumococcal vaccines.

In 1920, however, the bacteria (*S. pneumoniae*) would be renamed again to "*Diplococcus pneumoniae"* by Austrian physician, Anton Weichselbaum [35], after publishing a series of case reports and attempting to identify the causative agent of croupous or lobar pneumonia [36-39]. Weichselbaum gave the bacteria this name indirect reference to the bacteria being isolated from cases of pneumonia and appearing as pairs of cocci under a microscope. In 1974, the bacteria received the name of *Streptococcus pneumoniae* [40], for its characteristic growth pattern of chains of cocci in liquid media.

Disease [40]

As described previously, *Streptococcus pneumoniae* is a gram-positive organism that mainly appears in pairs that resemble the shape of a lancet (a triangular shaped surgical knife). As of 2011, a total of 92 distinct serotypes of *S. pneumoniae* had been identified, each with a unique combination of proteins embedded on the bacteria's polysaccharide capsule. This capsule is *S. pnuemoniae*'s strongest virulence factor and is what enables the bacteria to have a wide variety of disease presentations.

S. pnuemoniae is commonly found in the nasopharynx and throat of healthy individuals as a commensal bacterium; this is especially common in children and adults living/working with

children. Infection most often occurs in children between the ages of two and three, but usually does not result in any symptoms or disease dissipates shortly thereafter. However, during the course of infection, symptomatic or not, the affected individual continues to shed the bacteria via aerosolization/droplets from breathing, coughing and sneezing.

When exposed to the aerosolized droplets of an infected individual, the bacteria enters healthy hosts through their nasal cavity and attaches to the nasopharyngeal epithelial cells. After a short incubation period of one to three days, the pathogenesis of the infection is determined, and the bacteria can remain in the host's nasopharyngeal, where it can form a colony in the host. The host can become contagious to others or the bacteria can further spread to other organs (e.g. ears, lungs or sinuses) in the host, which will eventually result in disease. The pathogenesis of *S. pnuemoniae* is predominantly determined by the bacteria's serotype. Some serotypes have a greater association with disease or, in other words, have a greater likelihood of causing diseases. Some serotypes are found more commonly in children versus adults. Serotypes also differ between geographic regions and the time of year of which the illness presents. Serotypes with the highest mortality rates tend to be those with low disease potential and usually occur within elderly populations that were asymptomatically colonized with the bacteria and only developed pneumococcal diseases as a result of the weakened immune system from an influenza infection.

Pneumococcal disease has three primary paths of pathogenesis associated with the most common clinical presentations, these include pneumonia, sinusitis, and otitis media. If the bacteria spreads down bronchi into the lungs, is able to escape the lung's mucous defenses and migrate to the alveolus; pneumonia will develop as a result of *S. pnuemoniae* bacteria attached to the alveolar epithelium replicating and initiating host damage responses. The most common symptoms associated with the presentation are pleuritic chest pain, productive cough, dyspepsia, rapid breathing (tachypnea), low oxygenation (hypoxia), fever between 39 to 41 °C, rapid heart

rate (tachycardia), malaise and weakness; less common symptoms included: nausea, vomiting, and headaches. With proper medication and rest, pneumonia usually resolves with no further complications.

It is possible for further complications to arise from pneumococcal pneumonia if *S. pnuemoniae* spreads from the lungs to the bloodstream (invasive); where thanks to its polysaccharide capsule the bacteria is able to continue to avoid the host's immune system and replicate, resulting in bacteremia. Once in the bloodstream, *S. pnuemoniae* is able to continue to cause further complications, as the bacteria continue to spread and affect other organs. These can include osteomyelitis (infection of the bone), hemolytic uremic syndrome (damage to the kidney's blood vessel and low red blood cells and platelet counts), pericarditis (infection of the sac surrounding the heart), septic arthritis (infection of joints) and meningitis (infection of the central nervous system). All of these infections are very serious and require immediate treatment and possible hospitalization.

The other two routes in which *S. pnuemoniae* can spread from the nasopharynx are to the eustachian or auditory tube to the middle ear (otitis media), or the bacteria can spread throughout the sinus cavities resulting in sinusitis. Both of these routes are dead ends, in that once the bacteria reach the targeted organs it has no means of infecting other organs.

Prevention and Treatment

The first reported attempts to limit the spread of pneumococcal diseases by use of vaccination occurred in 1911 when Sir Almroth E. Wright et al. [42] inoculated South African gold miners with whole killed *S. pneumoniae* [43]. However, this initial attempted proved insufficient; as Sir Wright was basing his work off of his previous experience of developing a moderately successful vaccine for Typhoid Fever (*Salmonella typhi*) [44]. This resulted in him only including one of the two known pneumococcal serotypes in the vaccine. Sir Wright, also

failed to use a large enough inoculum to provided protection [17], due to larger injections being associated with discomfort.

That same year Julius Morganroth and Richard Levy [45] found that ethylhydrocupreine (optochin), a derivative of quinine, was able to inhibit the growth of *S. pneumoniae*, but had no significant effects on other streptococcus bacteria species. As a result, Morganroth and Kaufmann [46] experimented on mice using optochin and found great success in early trials. This success would be short-lived. As later studies would demonstrate that optochin had a limited clinical dose range [47,48] where it had a therapeutic effect before it reaches toxic levels. To make matters worse, *S. pneumoniae* was able to quickly develop resistance to optochin [49], rendering the compound an ineffective treatment that was eventually abandoned.

After scientists such as Isaeff, Neufeld and Rimpau had demonstrated that transfusing pneumococcal antiserum was an effective treatment in animals, it was only a matter of time before serotherapy was applied to humans. At the turn of the 19th century, antiserum was shown to be an effective treatment for diphtheria (*Corynebacterium diphtheriae*). However, it was unknown at the time that antiserum treats these diseases by two different methods. In the cases of *S. pneumoniae*, the transfer of antibodies assists the host immune system by opsonizing the bacteria cells [24], as described earlier; while in the cases of diphtheria, the antibodies in the antiserum bind to and disable toxins that are being produced by the pathogen before they can affect the body. This meant that the early attempts of using serotherapy were not as effective at treating *S. pneumoniae* as they had been with diphtheria. It was not until the 1920s that serotherapy became a viable form of therapy [50] as the different serotypes were starting to be identified. This allowed antisera to be matched to the serotype of pneumococcus that infected each patient, thereby drastically increasing the overall effectiveness of the treatment. However, the total cost of acquiring large enough quantities of human antiserum would prove to be

substantial, leading to it being abandoned. The side effects of serum sickness being associated with the use of non-human antiserum would limit the widespread use of this therapy method [51].

During this same time, the very first antimicrobial agents were starting to be produced. Among these was sulfanilamide. Sulfanilamide was used to treat pneumococcal diseases, but its uses were limited by more popular treatments, like the aforementioned serotherapy [44], and due to *S. pneumoniae* not being as susceptible to the drug as other bacteria were. It would not be until 1938 that Lionel Whitby and colleagues [52] published the findings of their systematic review of 64 derivatives and compounds related to sulfanilamide, in search of a treatment that had the desirable traits of low toxicity and good in-vitro activity (the procedures developed by Whitby during this review are still in use today for similar searches). Eventually, they came across 2-(ρ-aminobenzenesulfonamido) pyridine, or as we now known it, sulfapyridine. Not even two months after Whitby's publication, sulfapyridine was reported to decrease the overall case fatality rate of individuals with pneumonia at Dudley Road Hospital in Birmingham, England from 27 percent to 8 percent [53]. This success would be short-lived, as just five years after sulfapyridine's discovery, the first cases of *S. pneumoniae* sulfonamide-resistance were reported [54].

Another antimicrobial agent that was discovered around this same time (1939) by René Dubos [55] was gramicidin. Gramicidin was the first naturally occurring agent that showed antimicrobial capabilities against bacterial pathogens in-vitro. Ultimately, much like optochin, gramicidin medical uses would be limited as it proved to be toxic in mice [56] and dogs [57]. This failure led Dubos and colleagues [58] to reevaluate other antimicrobial compounds in 1940, one of which was penicillin. Penicillin was first discovered in 1929 by Alexander Fleming [59] after several of his petri dishes became contaminated with a fungus (*Penicillium chrysogenum)*

that inhibited the growth of his bacteria cultures. Penicillin would see limited clinical application shortly after its discovery, despite it showing superior potency against bacteria and lacking the toxicity of other treatments [60], due to the difficulty of isolating sufficient quantities of it to eliminate infection from patients. It would not be until 1941 [60] that penicillin would see wide clinical applications, as a team of researchers at Oxford, were able to develop a method of mass-producing penicillin. In the following two years, it would be reported that penicillin was used to treat 500 cases of staphylococcal and streptococcal infections, most of which showed signs of sulfonamide resistance [61]. In 1944 [62], penicillin was used to treat 46 cases of pneumococcal pneumonia and eight cases of pneumococcal empyema. Penicillin was continually used throughout the following years with great clinical success. Unfortunately, history would repeat itself as the first signs of penicillin resistance emerged in 1965 in Boston and in Australia in 1967 [63]. Then in 1977 and 1978 multiple outbreaks of multi-drug resistant strains of *S. pnuemoniae* were reported in South Africa [64,65]. Of 26 clinical isolates from the original outbreaks, 21 of the isolates were penicillin resistant, and five showed intermediate penicillin resistance with variable susceptibilities to macrolides, clindamycin, chloramphenicol, tetracycline, and trimethoprim-sulfamethoxazole.

With limited options available for the treatment of pneumococcal disease at the start of the 1920s, a large effort was made by researchers in the 1930s and 1940s [66-70] to find a vaccine that was effective at preventing further outbreaks of the disease. This push would eventually yield several advancements. The first being a general increase in the effectiveness of vaccines to convey protection against pneumococcal in healthy adults [71-73]. Another advancement came in 1937 when Felton [74] was able to develop and implement vaccines to stop an outbreak of *S. pneumoniae* at a state hospital. Finally, Paul Kaufman [75] was successfully able to demonstrate that vaccines containing two or more type-specific

polysaccharide conveyed greater immunity in elderly cohorts than traditional vaccines containing a single polysaccharide type. Despite these advancements, vaccines would fall out of the public favor, as antibacterial agents were thought to be a more effective way of dealing with pneumococcal disease [17]. It would not be until the 1960s that interest in vaccines for *S. pneumoniae* would reemerge, in thanks to Robert Austrian. This would eventually lead to the development of a multivalent vaccine in 1967. This vaccine was to contain the polysaccharide components of the 14 most common serotypes of *S. pneumoniae*, which at the time were responsible for approximately 80 percent of all cases of pneumococcal disease [27]. The 14-valent vaccine, dubbed pneumococcal conjugate vaccine 14 (PPSV14), would come to fruition in 1977 [27,76,77] and was shown to be 79 percent effective in preventing type-specific pneumococcal pneumonia and type-specific pneumococcal bacteremia in adults. Eventually, a 23-valent vaccine (PPSV23) was developed to replace the 14-valent. The 23-valent vaccine was released in 1983 [78] and has been evaluated to have an efficacy ranging from 55 to 76 percent [27,79-82], with the individual's age [83,84], immune status (i.e. immune competent or compromised) [85,86] and the interval since receiving the vaccination all playing significant roles in the vaccine's efficacy.

With an effective vaccine for children and adults developed, researchers turned their attention to developing a vaccine for infants, as they are the second largest at-risk population for *S. pnuemoniae* [79]. In February of 2000, the FDA approved the 7-valent pneumococcal conjugate vaccine (PCV7) [27,79] which was specifically designed to prevent the seven strains of *S. pneumoniae* that were responsible for approximately 61 percent of all pneumococcal cases in infants and young children (children under the age of five) [27]. The PCV7 vaccine was shown to have an overall vaccine efficacy in children younger than two years old of 80 percent after receiving at least one dose, 97 percent after receiving three primary doses and 95 percent

after receiving a booster [87]. The PCV7 vaccine was even shown to decrease the burden of disease in adults age 65 and older by 45 percent for the strains included in the PCV7 vaccine [87]. Ten years after its introduction, an improved version of the PCV7 vaccine was released that now covered an additional six strains of *S. pneumoniae* and would be known as the PCV13 vaccine [27,79]. The PCV13 had a slight improvement in the vaccine's efficacy as compared to PCV7 vaccine with the overall vaccine efficacy in children younger than two years old now being 86 percent after receiving at least one dose, 85 percent after receiving three primary doses and 91 percent after receiving the booster for the 13 included strains [86]. The year after PCV13 introduction, the FDA expanded the availability of the PCV13 to included individuals over the age of 50, as the PCV13 vaccine showed equal and, in some cases, greater immune response in the included population than of the PPSV23 vaccine. After the introduction of the PCV13 vaccine, the rates for the included strains dropped by 87 percent in children under the age of five and by 2014 the rate of disease of individuals over the age of 65 also dropped by 70 percent [79].

Currently, the Advisory Committee on Immunization Practices (ACIP) has recommended the PPSV23 vaccine for individuals ages two and older who have any underlying medical conditions that increase their risk of infection from *S. pneumoniae* and that all individuals over the age of 65 receive the vaccine; while the PCV13 vaccine is recommended for children between the 2 and 59 (5 years) months old, for individuals 6 to 64 years old with underlying conditions and all adults aged 65 years and older [87]. See Appendixes E-H for further details.

Project Description and Objectives

The Sedgwick County Division of Health (SCDOH) is responsible for investigating reports of Sedgwick County residents who have been infected with diseases that are considered significant threats to public health by the National Notifiable Disease Surveillance System (NNDSS) from the Centers for Disease Control and Prevention (CDC). These diseases are

considered reportable diseases, among which invasive *S. pneumoniae* is included. Cases of reportable diseases are reported to SCDOH by healthcare providers and clinical laboratories, after receiving positive identification of bacterial isolates collected from fluid and tissue samples. Once the Health Department has been notified an investigation is started, in tangent with Kansas Department of Health and Environment (KDHE), during which the medical provider is contacted for specific information about the patient and the infection. This information is then uploaded and stored on KS EpiTrax, Kansas's online case management system, for case tracking and later analysis.

As of 2015, SCDOH and other local Health Departments have been experiencing a large influx in the number of invasive *S. pneumoniae* cases, to the point that further inquiry has become necessary. As a result, an investigation was launched to answer the following questions:

1. Trend Analysis – How many more cases are occurring and are disease outcomes changing?
2. Case Demographics – Are any subpopulations being affected disproportionately by *S. pneumoniae*?
3. Comparing Counties' Mortality – Are participating counties experiencing higher odds of mortality?
4. Determine Vaccinated vs Unvaccinated Disease Outcomes – Is there a significant difference between vaccination status (vaccinated and unvaccinated), vaccination type and disease outcome?
5. Comparing Counties' Morbidity – Are any of the participating counties affected disproportionately by *S. pneumoniae*?

Chapter 2 – Methods (Complications)

The three Kansas County Health Departments that were originally contacted to participate in this study were: Reno, Johnson, and Shawnee County. These counties were selected for comparison with Sedgwick County based on Johnson County having a similar total population and demographics, Shawnee County lacking the characteristic increase in *S. pneumoniae* cases following 2015, and Reno County experiencing a similar increase in cases. Due to resource and time constraints, Reno County was eventually removed from this study due to data not being reported to Sedgwick County.

Data Collection

All subjects that were included in the study were laboratory confirmed invasive *S. pneumoniae* cases in the selected counties that were reported to each County's respective public health department between the dates of January 1, 2014, and December 31, 2017. The subject's demographic, vaccination/medical history, risk factors, the anatomic site from which the isolate was obtained, type of infection and antibiotic susceptibility were all collected from the KS EpiTrax System for each participating county. Due to limited information being reported regarding the vaccination histories for the included cases, the Kansas Health Information Network (KHIN) and Kansas Immunization Information System (WebIZ) databases were utilized; as well as contacting the subject's primary care provider, to obtain any missing information. Each County's epidemiology departments were responsible for acquiring this data for all reported cases that were to be included in the study. The participating Health Departments transferred and exported this data, formatted in Microsoft Excel (2007) (Microsoft Corporation, Redmond, Washington) files, to the SCDOH Epidemiology Program. Upon receiving the data, Sedgwick County reorganized it into a uniform standard format and consolidated it into a single database.

Invasive *S. pneumoniae* Frequency

Once the *S. pneumoniae* database was compiled, the data were summarized in frequency tables for comparison of study population between each county. Each frequency table compares the general population demographic information (gender, race/ethnicity, age in years and occupation), illness severity (total number of days hospitalized and type of illness) and underlying medical conditions between those that were vaccinated, unvaccinated and those whose vaccination status is currently unknown. All unconfirmed cases were excluded.

Invasive *S. pneumoniae* Rate

After the frequency tables were completed; the data summarization continued by constructing tables that allowed for the comparison of the cumulative incidence (CI) of *S. pneumoniae* associated with population demographic information (gender, race/ethnicity, age in years and occupation), disease mortality and vaccination status per 100,000 cases within each county for every year that the study covered.

The formula used to calculate rate is listed below:

$$\text{Cumulative Incidince} = \frac{\text{Number of Cases} \times 100{,}000}{\text{Total Population} - \left(\frac{1}{2} \times \text{Number of Cases}\right) + \left(\frac{1}{2} \times \text{Number of Births}\right) - \left(\frac{1}{2} \times \text{Number of Deaths}\right)}$$

For these calculations, estimates for the: total populations, number of births and number of deaths were acquired from KDHE's Kansas Information for Communities (KIC) website. CI calculations could not be performed for the vaccination statuses or types as there is currently no known reference as to what portion of the population has been vaccinated for *S. pneumoniae* or as to which type of vaccines they have received.

Chi-Square

The first statistical analysis that was performed on the data were chi-squares to determine if there were any statistically significant differences between the various populations. Using the formula listed below, O = observed, E = expected.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

For these calculations, population statistics for the relevant groups were acquired from KDHE's Kansas Information for Communities (KIC) website.

Once the chi-squares were calculated, they were then plugged into an online calculator, along with the degrees of freedom, to determine the P-value for each population frequency comparisons. Each County's "general" or total population was compared to their study population to determine if the study population was representative of the County's population as a whole and could give insight on if any gender, race/ethnicity or age group was being disproportionately affected by the disease, as they would be significantly over or under-represented in the study population.

A comparison between vaccination status, gender, race/ethnicity, age and mortality of disease for each county was performed to determine if there were any significant differences between each of the counties' study populations or if there were any significant difference in the populations of each county that were afflicted by *S. pneumoniae*.

The final chi-square compares the 2014 and 2015 study populations to the 2016 and 2017 study populations for each of the participating counties. This was done to see if each of the County's populations experienced any significant changes to their population demographics during these transition years that would account for the overall increase in the number of reported *S. pneumoniae* cases in 2016 and 2017.

Statistical Models

In order to determine the relationship between population demographics, medical status, and disease outcome, statistical models were developed to complete the last three study objectives. Logistical regression was used to determine the odds of mortality from invasive *S. pneumoniae* while controlling for population demographics and vaccination status and type and to model dichotomous outcomes from multi-leveled predictor variables (objectives three and four). This is desirable because the main disease outcome of interest is mortality. Models one through three reflect this basic question but do so with different relevant information and model design as designated by SCDOH. General Linear Model 1 – Logistic Regression, listed below, was used to determine if the patient's odds of mortality were affected by the county in which they reside, their relevant demographic information (race/ethnicity and age), their vaccination status and if they have any underlying medical conditions. This model was run to answer objective three's question, or if any of the participating counties experiencing higher odds of mortality.

General Linear Model 1 – Logistic Regression

$$\ln\left(\frac{\mathrm{p}_{\mathrm{Mortality}}}{1-\mathrm{p}_{\mathrm{Mortality}}}\right) = \beta_0 + \beta X_{\mathrm{County}} + \beta X_{\mathrm{Race/Ethnicity}} + \beta X_{\mathrm{Age\ Onset}} + \beta X_{\mathrm{Vax\ Status}} + \beta X_{\mathrm{Medical\ \ Cond.}}$$

The second logistic regression set, General Linear Model 2 – Logistic Regression, had multiple parts. Model 2.1 looked at how the patient's odds of mortality was affected by the county in which they reside, their vaccination status, the number of days they were hospitalized, the type of infection they had and if they have any underlying medical conditions. This model was used to answer the first part of objective four, or if the vaccination status of the patient had any effect on their outcome.

General Linear Model 2 – Logistic Regression

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{County}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

General Linear Model 3 – Logistic Regression was used to determine how the patient's odds of mortality were affected by the patient's age, the vaccination type they received (if received), the number of days they were hospitalized, the type of infection they had and if they have any underlying medical conditions. This model was used to answer the second part of objective four: if the vaccination type that the patient received had any effect on their outcome. This model also included the patient's age of onset of disease to account for the fact that the PPSV23 vaccine is primarily only recommended to individuals over the age of 65 or with specific medical conditions.

General Linear Model 3 – Logistic Regression

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{Age Onset}} + \beta X_{\text{Vax Type}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}} + \beta X_{\text{Medical Cond.}}$$

General Linear Model 4 – Poisson Regression was designed to determine if the county of which a person resides, their age and/or their race/ethnicity have a statistically significant effect on the number of *S. pneumoniae* cases. This model was used to answer the question from the fifth objective: if any of the counties that participated in the study were being disproportionality affected by invasive *S. pneumoniae.*

General Linear Model 4 – Poisson Regression

$$\text{Counts}(\text{Cases of } S.pneumoniae) = \beta_0 + \beta_{\text{County}} X + \beta_{\text{Age Onset}} X + \beta_{\text{Race/Ethnicity}} X$$

The final model that was utilized was to determine which variables were the best predictors of the patient's odds of mortality. This model was designed by performing three stepwise regressions. The first was a forward selection regression, moving from an unsaturated model to a saturated model. This was followed by a backward elimination regression, moving

from a saturated model to an unsaturated model. The final stepwise regression incorporated both forward and backward stepwise regressions simultaneously, or bidirectional elimination and will be referred to as 'Both Stepwise Regression'.

The forward stepwise regression only reported one model in addition to the over-saturated input model (Table 2.1). The output model had an identical Akaike information criterion (AIC) as the over-saturated model, hinting at it have no greater predictive capabilities.

Table 2.1 Forward Stepwise Regression Using Mortality as the Outcome (N = 445)

Stepwise Regression – Forward		
#	Model	AIC
0	$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{Year}} + \beta X_{\text{County}} + \beta X_{\text{Race \& Ethnicity}} + \beta X_{\text{Age Onset}} + \beta X_{\text{Medical Cond.}} + \beta X_{\text{Vax Status}} + \beta X_{\text{Vax Type.}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}}$	196.74
1	$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{\text{Year}} + \beta X_{\text{County}} + \beta X_{\text{Medical Cond.}} + \beta X_{\text{Vax Status.}} + \beta X_{\text{Days Hosp.}} + \beta X_{\text{Infection Type}}$	196.74

The backward stepwise regression resulted in a total output of four models in addition to the input model (Table 2.2). The final model that the stepwise regression converged on had an AIC of 189.17 and included the variables of year, county of residence, underlying medical conditions, vaccine type and the total number of days hospitalized.

Table 2.2 Backwards Stepwise Regression Using Mortality as the Outcome (N = 445)

Stepwise Regression - Backward		
#	Model	AIC
0	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Race\ \&\ Ethnicity} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Status} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	196.74
1	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Race\ \&\ Ethnicity} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	196.74
2	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	190.95
3	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	189.63
4	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.}$	189.17

The final stepwise regression was similar to the backward regression with four output models (Table 2.3) and converged on the same final output model with an AIC of 189.17.

Table 2.3 Both Stepwise Regressions with Mortality as the Outcome (N = 445)

Stepwise Regressions - Both		
#	Model	AIC
0	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Race\ \&\ Ethnicity} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Status} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	196.74
1	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Race\ \&\ Ethnicity} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	196.74
2	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Age\ Onset} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	190.95
3	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.} + \beta X_{Infection\ Type}$	189.63
4	$\ln\left(\frac{p_{Mortality}}{1-p_{Mortality}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{Medical\ Cond.} + \beta X_{Vax\ Type.} + \beta X_{Days\ Hosp.}$	189.17

Due to the backward and both stepwise regressions converging on the same model with an overall lower AIC than the forwards stepwise regression, this model was determined to be the

best predictor of the patient's odds of mortality given the study's data and was included as General Linear Model 5. Furthermore, a Hosmer-Lemeshow goodness of fit test was performed on General Linear Model 5 – Logistic Regression, to determine whether the observed rate of mortality in the cases of invasive *S. pneumoniae*, matched the rate of mortality predicted by the model.

General Linear Model 5 – Logistic Regression

$$\ln\left(\frac{p_{\text{Mortality}}}{1-p_{\text{Mortality}}}\right) = \beta_0 + \beta X_{Year} + \beta X_{County} + \beta X_{\text{Medical Cond.}} + \beta X_{Vax\ Type.} + \beta X_{\text{Days Hosp.}}$$

Chapter 3 – Results (Climax)

Invasive *S. pneumoniae* Frequency

Sedgwick County had the most cases of Invasive *S. pneumoniae* at 229, while Johnson County had a total of 125 and Shawnee County had the least with only 91 cases. Approximately 46 percent of all the included cases had been vaccinated for *S. pneumoniae* at some point in their life. There was a near even split between men and women, with men making up 224 of the total cases, while women represented 221 cases. Finally, 79 percent of all cases had some underlying medical condition prior to being diagnosed with Invasive *S. pneumoniae.* Table 3.1 displays Johnson County's cases (N = 125), Table 3.2 displays Sedgwick County's cases (N = 229) and Table 3.3 displays Shawnee County's cases (N = 91).

Table 3.1 Frequency of Confirmed Invasive *S. pneumoniae* Cases in Johnson County, 2014-2017 (N = 125)

Characteristic or Variable	Vaccinated	Unvaccinated	Unknown
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Males	27 (21.60)	17 (13.60)	17 (13.60)
Females	33 (26.40)	13 (10.40)	18 (14.40)
Race/Ethnicity			
White	51 (40.80)	25 (20.00)	30 (24.00)
Black/African American	3 (2.40)	1 (0.80)	2 (1.60)
Hispanic	4 (3.20)	4 (3.20)	2 (1.60)
Other	1 (0.80)	0 (0.00)	1 (0.80)
Asian	1 (0.80)	0 (0.00)	1 (0.80)
American Indian/Alaskan Native	0 (0.00)	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)	0 (0.00)
Age, years			
≤49	16 (12.80)	14 (11.20)	11 (8.80)
50-64	12 (9.80)	9 (7.20)	6 (4.80)
65-74	18 (14.40)	2 (1.60)	10 (8.00)
75-84	5 (4.00)	3 (2.40)	3 (2.40)
≥85	9 (7.20)	2 (1.60)	5 (4.00)
Occupation			
Employed	6 (4.80)	7 (5.60)	8 (6.40)
Unemployed	3 (2.40)	1 (0.80)	2 (1.60)
Retired	19 (15.20)	5 (0.40)	14 (11.20)
*Other**	6 (4.80)	1 (0.80)	3 (2.40)
Unknown	26 (20.80)	16 (12.80)	8 (6.40)
Days Hospitalized, days			
0-7	12 (9.60)	6 (4.80)	11 (8.80)
8-15	1 (0.80)	2 (1.60)	0 (0.00)
16-30	1 (0.80)	0 (0.00)	0 (0.00)
>30	0 (0.00)	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)	0 (0.00)
Infection Type			
Bacteremia	22 (17.6)	41 (32.8)	26 (20.8)
Pneumonia	40 (32.0)	20 (16.0)	28 (22.40)
Meningitis	1 (0.80)	3 (2.40)	4 (3.20)
Cellulitis	1 (0.80)	0 (0.00)	1 (0.80)
Septic arthritis	1 (0.80)	0 (0.00)	0 (0.00)
Osteomyelitis	1 (0.80)	0 (0.00)	0 (0.00)
Otitis media	2 (1.60)	0 (0.00)	2 (1.60)
Other	9 (7.20)	2 (1.60)	6 (4.80)
Underlying Medical Condition/Prior Illness			
Yes	42 (33.60)	18 (14.40)	22 (17.60)
No	18 (14.4)	8 (6.40)	13 (10.40)
Unknown	0 (0.00)	4 (3.20)	0 (0.00)

*Other = minor, student, homeless and disabled

Table 3.2 Frequency of Invasive *S. pneumoniae* Cases, Sedgwick County, 2014-2017 (N = 229)

Characteristic or Variable	Vaccinated	Unvaccinated	Unknown
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Males	46 (20.09)	23 (10.04)	53 (23.14)
Females	37 (16.16)	22 (9.61)	48 (20.96)
Race/Ethnicity			
White	69 (30.13)	35 (15.28)	72 (31.44)
Black/African American	9 (3.93)	10 (4.37)	21 (9.17)
Hispanic	3 (1.31)	0 (0.00)	5 (2.18)
Other	2 (0.87)	0 (0.00)	1 (0.44)
American Indian/Alaskan Native	1 (0.44)	0 (0.00)	1 (0.44)
Asian	1 (0.44)	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)	2 (0.87)
Age, years			
≤49	17 (7.42)	8 (3.49)	27 (11.79)
50-64	27 (11.79)	17 (7.42)	43 (18.78)
65-74	16 (6.99)	12 (5.24)	13 (5.68)
75-84	16 (6.99)	6 (2.62)	9 (3.93)
≥85	7 (3.06)	2 (0.87)	9 (3.93)
Occupation			
Employed	9 (3.93)	7 (3.06)	16 (6.99)
Unemployed	12 (5.24)	15 (6.55)	28 (12.23)
Retired	33 (14.41)	15 (6.55)	32 (13.97)
*Other**	16 (6.99)	3 (1.31)	13 (5.68)
Unknown	13 (5.68)	5 (2.18)	7 (3.06)
Days Hospitalized, days			
0-7	51 (22.27)	26 (11.35)	67 (29.26)
8-15	18 (7.86)	8 (3.49)	12 (5.24)
16-30	2 (0.87)	3 (1.31)	5 (2.18)
>30	1 (0.44)	0 (0.00)	2 (0.87)
Unknown	11 (4.80)	8 (3.49)	15 (6.55)
Infection Type			
Bacteremia	20 (8.73)	17 (7.42)	31 (13.54)
Pneumonia	51 (22.27)	27 (11.79)	58 (25.33)
Meningitis	10 (4.37)	5 (2.18)	7 (3.06)
Cellulitis	1 (0.44)	1 (0.44)	2 (0.87)
Septic arthritis	0 (0.00)	2 (0.87)	1 (0.44)
Osteomyelitis	0 (0.00)	1 (0.44)	0 (0.00)
Otitis media	2 (0.87)	0 (0.00)	0 (0.00)
Other	2 (0.87)	1 (0.44)	3 (1.31)
Underlying Medical Condition/Prior Illness			
Yes	74 (32.31)	40 (17.47)	88 (38.43)
No	7 (3.06)	5 (2.18)	8 (3.49)
Unknown	2 (0.87)	0 (0.00)	5 (2.18)

*Other = minor, student, homeless and disabled

Table 3.3 Frequency of Invasive *S. pneumoniae* Cases, Shawnee County, 2014-2017 (N = 91)

Characteristic or Variable	Vaccinated	Unvaccinated	Unknown
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Males	28 (30.77)	0 (0.00)	13 (14.29)
Females	32 (35.16)	1 (1.10)	17 (18.68)
Race/Ethnicity			
White	46 (50.55)	1 (1.10)	23 (25.27)
Black/African American	9 (9.89)	0 (0.00)	6 (6.59)
Hispanic	4 (4.400	0 (0.00)	1 (1.10)
Other	1 (1.10)	0 (0.00)	0 (0.00)
Asian	0 (0.00)	0 (0.00)	0 (0.00)
American Indian/Alaskan Native	1 (1.10)	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)	0 (0.00)
Age, years			
≤49	19 (20.88)	0 (0.00)	10 (10.99)
50-64	18 (19.78)	1 (1.10)	11 (12.09)
65-74	14 (15.38)	0 (0.00)	6 (6.59)
75-84	5 (5.49)	0 (0.00)	2 (2.20)
≥85	4 (4.40)	0 (0.00)	1 (1.10)
Occupation			
Employed	9 (9.89)	1 (1.10)	8 (8.79)
Unemployed	9 (9.89)	0 (0.00)	8 (8.79)
Retired	20 (21.99)	0 (0.00)	8 (8.79)
*Other**	19 (20.88)	0 (0.00)	2 (2.20)
Unknown	3 (3.30)	0 (0.00)	4 (2.20)
Days Hospitalized, days			
0-7	33 (36.26)	1 (1.10)	13 (14.29)
8-15	13 (14.29)	0 (0.00)	5 (5.49)
16-30	2 (2.20)	0 (0.00)	1 (1.10)
>30	1 (1.10)	0 (0.00)	0 (0.00)
Unknown	0 (0.00)	0 (0.00)	0 (0.00)
Infection Type			
Bacteremia	13 (14.29)	0 (0.00)	6 (6.59)
Pneumonia	46 (50.55)	0 (0.00)	27 (29.67)
Meningitis	4 (4.40)	0 (0.00)	2 (2.20)
Cellulitis	1 (1.10)	0 (0.00)	0 (0.00)
Septic arthritis	0 (0.00)	0 (0.00)	0 (0.00)
Osteomyelitis	0 (0.00)	0 (0.00)	0 (0.00)
Otitis media	1 (1.10)	0 (0.00)	0 (0.00)
Other	6 (6.59)	0 (0.00)	3 (3.30)
Underlying Medical Condition/Prior Illness			
Yes	45 (49.45)	0 (0.00)	22 (24.18)
No	10 (10.99)	0 (0.00)	6 (6.59)
Unknown	5 (5.49)	1 (1.10)	2 (2.20)

*Other = minor, student, homeless and disabled

Invasive *S. pneumoniae* Rate

2017 saw the highest rates of mortality caused by invasive *S. pneumonia* for each of the counties. Individuals 85 and older higher rates of *S. pneumonia* than any of the other age groups and Blacks/African Americans experienced higher rates of Invasive *S. pneumoniae* than Whites and Hispanics. Table 3.4 displays Johnson County's cases (N = 125), Table 3.5 displays Sedgwick County's cases (N = 229) and Table 3.6 displays Shawnee County's cases (N = 91).

Table 3.4 Rate of Invasive *S. pneumoniae*, Johnson County, 2014-2017 (N = 125)

Characteristic or Variable	2014		2015		2016		2017	
	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate
Mortality								
Died	3 (2.40)	78.1148	1 (0.80)	24.6761	0 (0.00)	0.00	4 (3.20)	95.9003
Recovered	16 (12.80)	2.7776	33 (26.40)	5.6713	32 (25.60)	5.4592	36 (28.80)	6.0741
Unknown	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-
Age								
≤49	7 (5.60)	1.7818	16 (12.80)	4.0546	9 (7.20)	2.2789	8 (6.40)	2.0079
50-64	3 (2.40)	2.6801	5 (4.00)	4.4340	7 (5.60)	6.1984	12 (9.60)	10.6376
65-74	4 (3.20)	9.6660	7 (5.60)	15.8638	10 (8.00)	21.2441	9 (7.20)	18.1393
75-84	2 (1.60)	10.1812	5 (4.00)	25.0294	1 (0.80)	4.8665	2 (1.60)	9.3153
≥85	3 (2.40)	29.3499	1 (0.80)	9.6186	5 (4.00)	46.8165	6 (4.80)	57.9318
Gender								
Males	8 (6.40)	2.8523	17 (13.6)	5.9954	17 (13.6)	5.9529	19 (15.20)	6.5705
Females	11 (8.80)	3.7676	17 (13.6)	5.7693	15 (12.0)	5.0506	18 (14.40)	6.0000
Race/Ethnicity								
White	19 (15.20)	4.0294	28 (22.40)	5.8929	29 (23.20)	6.0649	30 (24.00)	6.2344
Black/African American	0 (0.00)	0.00	2 (1.60)	6.4200	3 (2.40)	9.6491	1 (0.80)	3.1522
Hispanic	1 (0.80)	2.3311	4 (3.20)	9.1995	4 (3.20)	9.0885	1 (0.80)	2.1939
Other	0 (0.00)	0.00	0 (0.00)	0.00	1 (0.80)	3.0331	1 (0.80)	2.8937
Asian	0 (0.00)	0.00	0 (0.00)	0.00	1 (0.80)	2.9421	1 (0.80)	2.8083
American Indian/Alaskan Native	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00
Unknown	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-
Vaccination Status								
Vaccinated	7 (5.60)	-	14 (11.20)	-	16 (12.80)	-	23 (18.40)	-
Conjugate	1 (0.80)	-	10 (8.00)	-	10 (8.00)	-	14 (11.20)	-
Polysaccharide	6 (4.80)	-	5 (4.00)	-	7 (5.60)	-	16 (12.80)	-
Both	0 (0.00)	-	1 (0.80)	-	1 (0.80)	-	7 (5.60)	-
Unvaccinated	9 (7.20)	-	14 (11.20)	-	7 (5.60)	-	0 (0.00)	-
Unknown	3 (2.40)	-	6 (4.80)	-	9 (7.20)	-	7 (5.60)	-

Table 3.5 Rate of Invasive *S. pneumoniae*, Sedgwick County, 2014-2017 (N = 229)

Characteristic or Variable	2014		2015		2016		2017	
	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate
Mortality								
Died	11 (4.80)	0.2155	4 (1.75)	0.0780	7 (3.06)	0.1363	13 (5.68)	0.2525
Recovered	25 (10.92)	0.4899	29 (12.66)	0.5653	64 (27.95)	1.2467	75 (32.75)	1.4566
Unknown	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	1 (0.44)	-
Age								
≤49	8 (3.49)	0.2304	7 (3.06)	0.2013	18 (7.86)	0.5195	19 (8.30)	0.5494
50-64	10 (4.37)	1.0370	15 (6.55)	1.5541	23 (10.04)	2.3813	39 (17.03)	4.0747
65-74	10 (4.37)	2.7440	5 (2.18)	1.2999	14 (6.11)	3.5033	12 (5.24)	2.8255
75-84	4 (1.75)	2.0330	4 (1.75)	2.0403	11 (4.80)	5.5811	12 (5.24)	5.9527
≥85	4 (1.75)	4.4668	2 (0.87)	2.1853	5 (2.18)	5.4245	7 (3.06)	7.3937
Gender								
Males	22 (9.61)	0.8762	18 (7.86)	0.7118	32 (13.97)	1.2699	50 (21.83)	1.9768
Females	14 (6.11)	0.5478	15 (6.55)	0.5849	39 (17.03)	1.5133	39 (17.03)	1.5088
Race/Ethnicity								
White	24 (10.48)	0.6696	27 (11.79)	0.7541	53 (23.14)	1.4787	72 (31.44)	2.0128
Black/African American	8 (3.49)	1.5547	4 (1.75)	0.7671	14 (6.11)	2.7353	14 (6.11)	2.7301
Hispanic	2 (0.87)	0.2803	0 (0.00)	0.00	4 (1.75)	0.5399	2 (0.87)	0.2643
Other	1 (0.44)	0.3454	1 (0.44)	0.3354	0 (0.00)	0.00	1 (0.44)	0.3325
Asian	0 (0.00)	0.00	1 (0.44)	0.4111	0 (0.00)	0.00	1 (0.44)	0.4040
American Indian/Alaskan Native	1 (0.44)	1.8023	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.44)	0.00
Unknown	1 (0.44)	-	1 (0.44)	-	0 (0.00)	-	0 (0.44)	-
Vaccination Status								
Vaccinated	14 (6.60)	-	12 (5.24)	-	30 (13.10)	-	27 (11.79)	-
Conjugate	1 (0.44)	-	2 (0.87)	-	10 (4.37)	-	5 (2.18)	-
Polysaccharide	12 (5.24)	-	8 (3.49)	-	10 (4.37)	-	10 (4.37)	-
Both	1 (0.44)	-	2 (0.87)	-	10 (4.37)	-	12 (5.24)	-
Unvaccinated	11 (4.80)	-	8 (3.49)	-	16 (6.99)	-	10 (4.37)	-
Unknown	11 (4.80)	-	13 (5.68)	-	25 (10.92)	-	52 (22.71)	-

Table 3.6 Rate of Invasive *S. pneumoniae*, Shawnee County, 2014-2017 (N = 91)

Characteristic or Variable	2014		2015		2016		2017	
	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate	Frequency (%)	Rate
Patient Death								
Yes	0 (0.00)	0.00	1 (1.10)	0.0559	1 (1.10)	0.0561	1 (1.10)	0.0561
No	4 (4.40)	0.2239	14 (15.38)	0.7825	34 (37.36)	1.9070	36 (39.56)	2.0195
Unknown	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-
Age								
≤49	3 (3.30)	0.2660	5 (5.49)	0.4445	13 (14.29)	1.1679	8 (8.79)	0.7211
50-64	1 (1.10)	0.2706	5 (5.49)	1.3599	12 (13.19)	3.2866	12 (13.19)	3.3444
65-74	0 (0.00)	0.00	4 (4.40)	2.4334	7 (7.69)	4.0779	9 (9.89)	5.0160
75-84	0 (0.00)	0.00	1 (1.10)	1.1449	0 (0.00)	0.00	6 (6.59)	6.6087
≥85	0 (0.00)	0.00	0 (0.00)	0.00	3 (3.30)	6.9180	2 (2.20)	4.6264
Gender								
Males	2 (2.20)	0.2326	8 (8.79)	0.9259	13 (14.29)	1.5143	18 (19.78)	2.0956
Females	2 (2.20)	0.2186	7 (7.69)	0.7661	22 (24.18)	2.4084	19 (20.88)	2.0802
Race/Ethnicity								
White	2 (2.20)	0.1471	12 (13.19)	0.8857	27 (29.67)	2.0015	29 (31.87)	2.1608
Black/African American	1 (1.10)	0.5921	1 (1.10)	0.5907	6 (6.59)	3.5962	7 (7.69)	4.2094
Hispanic	0 (0.00)	0.00	2 (2.20)	0.9316	2 (2.20)	0.9261	1 (1.10)	0.4490
Other	1 (1.10)	2.0290	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00
Asian	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00
American Indian/Alaskan Native	1 (1.10)	4.8088	0 (0.00)	0.00	0 (0.00)	0.00	0 (0.00)	0.00
Unknown	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-
Vaccination Status								
Vaccinated	4 (4.40)	-	8 (8.79)	-	25 (27.47)	-	23 (25.27)	-
Conjugate	0 (0.00)	-	3 (3.30)	-	5 (5.49)	-	6 (6.60)	-
Polysaccharide	2 (2.20)	-	4 (4.40)	-	9 (9.89)	-	5 (5.49)	-
Both	2 (2.20)	-	1 (1.10)	-	11 (12.09)	-	12 (13.19)	-
Unvaccinated	0 (0.00)	-	0 (0.00)	-	0 (0.00)	-	1 (1.10)	-
Unknown	0 (0.00)	-	7 (7.69)	-	10 (10.99)	-	13 (14.29)	-

Chi-Square

Table 3.7 shows the comparison between each County's "general" or total population to their study population. These comparisons were performed to determine if the study population was representative of the County's population as a whole and could give insight on if any gender, race/ethnicity or age group was being disproportionately affected by the disease, as they would be significantly over- or under-represented in the study population. No significant differences between each County's general population and their study population in the selected categories and no significant differences between the total study population and Kansas's population as a whole were identified.

Table 3.7 Comparison of Population Frequencies between Sedgwick County, Shawnee County, and Johnson County and Kansas's General Population to the Population of Confirmed Invasive *S. pneumoniae* Cases, 2014-2017

Characteristic or Variable	Sedgwick		Shawnee		Johnson		Kansas	
	x^2	P-value	x^2	P-value	x^2	P-value	x^2	P-value
Gender								
Males	0.0028	0.9578	0.0025	0.9601	0.0000	>0.9999	0.0000	>0.9999
Females	0.0028	0.9578	0.0023	0.9617	0.0000	>0.9999	0.0000	>0.9999
Race/Ethnicity								
White	0.0069	0.9998	0.0002	>0.9999	0.0012	>0.9999	0.0003	>0.9999
Black/African American	0.0551	0.9966	0.0534	0.9968	0.0005	>0.9999	0.0746	0.9947
Hispanic or Latino	0.0812	0.9940	0.0352	0.9982	0.0003	>0.9999	0.0358	0.9982
Other	0.0347	0.9983	0.0105	0.9997	0.0283	.9987	0.0189	0.9993
Age, years								
0-49	0.3000	0.9898	0.1518	0.9973	0.1765	0.9963	0.2256	0.9941
50-64	0.1950	0.9955	0.0014	>0.9999	0.0026	>0.9999	0.0912	0.9990
65-74	0.1357	0.9978	0.1670	0.9967	0.3306	0.9878	0.1800	0.9962
75-84	0.2415	0.9933	0.0152	>0.9999	0.0762	0.9993	0.1005	0.9988
≥85	0.2040	0.9951	0.0391	0.9998	0.6158	0.9613	0.1931	0.9956

*= P-value of less than or equal to .05
** = P-value of less than or equal to .01

Table 3.8 shows the comparison between vaccination status, gender, race/ethnicity, age and mortality of disease for each County's study populations. Several significant differences in vaccination status between Shawnee County's and Sedgwick County's study populations were

identified. Specifically, there were significant differences between the portion of Sedgwick County's populations that are vaccinated and unvaccinated as compared to the portion these groups make up of Shawnee County's population.

Table 3.8 Comparison of Population Frequencies between Sedgwick County, Shawnee County, and Johnson County Confirmed Invasive *S. pneumoniae* Cases, 2014-2017

Characteristic or Variable	Shawnee vs Sedgwick		Johnson vs Sedgwick		Johnson vs Shawnee	
	x^2	P-value	x^2	P-value	x^2	P-value
Vaccination Status						
Vaccinated	24.3238	<0.0001**	0.0381	0.9811	0.0488	0.9759
Conjugate	0.0720	0.9646	0.5160	0.7726	0.1034	0.9496
Polysaccharide	0.0116	0.9942	0.0542	0.9732	0.0124	0.9938
Both	0.2855	0.8670	0.0127	0.9937	0.1599	0.9232
Unvaccinated	17.5116	0.0002**	0.0096	0.9952	4.7726	0.0920
Unknown	2.8090	0.2455	0.1317	0.9363	0.0510	0.9748
Gender						
Males	1.2713	0.2595	0.0038	0.9508	0.0029	0.9571
Females	1.4498	0.2286	0.0043	0.9477	0.0027	.9586
Race/Ethnicity						
White	<0.0001	>0.9999	0.0082	0.9998	0.0073	0.9998
Black/African American	0.0561	0.9965	0.0919	0.9928	0.2844	0.9629
Hispanic or Latino	1.1461	0.7660	0.0581	0.9963	0.0078	0.9998
Other	0.0337	0.9984	0.0006	>0.9999	0.0016	>0.9999
Age, years						
≤49	3.6947	0.4489	0.0449	0.9998	0.0003	>0.9999
50-64	0.6633	0.9558	0.0707	0.9994	0.0598	0.9996
65-74	0.9300	0.9201	0.0208	0.9999	0.0017	>0.9999
75-84	2.5275	0.6397	0.0166	>0.9999	0.0014	>0.9999
≥85	0.7146	0.9495	0.0310	0.9999	0.0417	0.9998
Mortality						
Died	0.0940	0.9541	0.0516	0.9997	0.0292	0.9999
Recovered	0.0183	0.9909	0.0103	>0.9999	0.0010	>0.9999
Unknown	0.0044	0.9978	0.0044	>0.9999	-	-

*= P-value of less than or equal to .05
** = P-value of less than or equal to .01

Table 3.9 compares the 2014 and 2015 study populations to the 2016 and 2017 study populations for each of the participating counties. No significant differences were found between any County's 2014-2015 and 2016-2017 *S. pneumoniae* case populations.

Table 3.9 Frequency Comparison between Sedgwick County's, Shawnee County's, and Johnson County's 2014-2015 to 2016-2017 Populations of Confirmed Invasive *S. pneumoniae* Cases

Characteristic or Variable	Sedgwick		Shawnee		Johnson	
	x^2	P-value	x^2	P-value	x^2	P-value
Vaccination Status						
Vaccinated	0.1614	0.9225	1.1868	0.5524	0.1234	0.9402
Conjugate	0.2096	0.9005	0.2344	0.8894	0.1229	0.9404
Polysaccharide	0.0000	>0.9999	0.1172	0.9431	0.1047	0.9490
Both	0.5255	0.7689	1.4652	0.4807	0.3920	0.8220
Unvaccinated	0.0113	0.9944	-	-	0.0890	0.9565
Unknown	0.5111	0.7745	0.4019	0.8180	0.0436	0.9784
Gender						
Males	0.1926	0.6608	0.4846	0.4863	0.0387	0.8440
Females	0.3615	0.5477	1.2503	0.2635	0.0183	0.8924
Race/Ethnicity						
White	0.4689	0.4935	1.3846	0.2393	0.0245	0.8756
Black/African American	0.0932	0.7601	0.6648	0.4149	0.0160	0.8993
Hispanic	0.0349	0.8518	0.0055	0.9409	0.0000	>0.9999
Other	0.0022	0.9626	0.0110	0.9165	-	-
Unknown	0.0087	0.9257	-	-	-	-
Age, years						
≤49	0.1409	0.7074	0.2321	0.6300	0.0125	0.9110
50-64	0.2391	0.6249	0.5934	0.4411	0.1210	0.7280
65-74	0.0352	0.8512	0.3956	0.5294	0.0465	0.8293
75-84	0.1228	0.7260	0.2747	0.6002	0.0183	0.8924
≥85	0.0262	0.8714	-	-	0.0980	0.7542
Mortality						
Died	0.0073	0.9319	0.0110	0.9165	0.0000	>0.9999
Recovered	0.5843	0.4446	1.6508	0.1989	0.0589	0.8082
Unknown	-	-	-	-	-	-

*= P-value of less than or equal to .05

** = P-value of less than or equal to .01

Statistical Models

The results for each statistical model are reported in this chapter in table format, with each included variable having an odds ratio (OR) with accompanying two-tailed 95 percent confidence intervals.

The results from Model 1, shown below in Table 3.10, showed that the only variables that had a significant relationship to the patient's mortality were the county of which they reside and underlying medical conditions. Shawnee County had the highest odds of mortality for individuals afflicted with *S. pneumoniae*. Residents of Shawnee County that has been infected by invasive *S. pneumoniae* were 7.0 times as likely to succumb to the disease than Sedgwick County residents. Individuals with underlying medical conditions were 8.1 times as likely to succumb to the *S. pneumoniae* than individuals with no underlying medical conditions; while individuals with unknown status underlying medical conditions were 24.5 times as likely to die from *S. pneumoniae* than individuals with no underlying medical conditions. All other included variables were found to have an insignificant relationship with patient mortality. The null deviance of General Linear Model 1 – Logistic Regression was 301.05 on 448 degrees of freedom, while the residual deviance was 267.50 on 442 degrees of freedom.

Table 3.10 County, Race/Ethnicity, Age Onset, Vaccination Status, and Medical Condition Variables Associated with Mortality as Compared to Survival of Invasive *S. pneumoniae*

Characteristic or Variable	**Odds Ratio**	**Lower CI**	**Upper CI**
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	2.1716	0.9880	5.2670
Shawnee County	7.0311*	2.2498	32.1158
Race/Ethnicity	1.1022	0.6774	1.9507
Age, years	0.9950	0.9781	1.0111
Vaccination Status	0.6738	0.4237	1.0440
Underlying Medical Condition (Reference No)			
Yes	8.1232*	2.5796	25.7108
Unknown	24.4750*	4.6904	192.5870

*= Odds Ratio Significant

The results from General Linear Model 2 – Logistic Regression, shown in Table 3.11, demonstrate that again the county of which the individual resides, and underlying medical conditions had a significant relationship to the patient's mortality. Residents of Shawnee County infected with *S. pneumoniae* were 6.8 times as likely to die from invasive *S. pneumoniae* than Sedgwick County residents. Individuals with underlying medical conditions were 13.4 times as likely to succumb to the *S. pneumoniae* than individuals with no underlying medical conditions; while individuals with unknown status underlying medical conditions were 45.4 times as likely to die from *S. pneumoniae* than individuals with no underlying medical conditions. All other included variables were found to have an insignificant relationship with patient mortality. The null deviance of General Linear Model 2 – Logistic Regression was 301.05 on 448 degrees of freedom, while the residual deviance was 265.65 on 442 degrees of freedom.

Table 3.11 County, Vaccination Status, Days Hospitalized, Type of Infection, and Medical Condition Variables Associated with Mortality as Compared to Survival of Invasive *S. pneumoniae*

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	1.3100	0.1230	2.7225
Shawnee County	6.8452*	2.1468	32.0031
Vaccination Status	0.6721	0.4217	1.0434
Number of Days Hospitalized	1.0074	0.9977	1.0182
Type of Infection	1.3667	0.7847	2.5929
Underlying Medical Condition (Reference No)			
Yes	13.4057*	3.6325	52.7256
Unknown	45.3558*	7.8409	390.7720

*= Odds Ratio Significant

The results from General Linear Model 3 – Logistic Regression are shown in Table 3.12. The only variable the showed a significant relationship with patient mortality was having an underlying medical condition. Individuals with underlying medical conditions were 9.2 times as likely to succumb to the *S. pneumoniae* than individuals with no underlying medical conditions;

while individuals with unknown status underlying medical conditions were 31.2 times as likely to die from *S. pneumoniae* than individuals with no underlying medical conditions. The null deviance of General Linear Model 3 – Logistic Regression was 301.05 on 448 degrees of freedom, while the residual deviance was 278.44 on 442 degrees of freedom.

Table 3.12 Vaccination Type, Days Hospitalized, Age Onset, Type of Infection, Medical Condition and Race/Ethnicity Variables Associated with Mortality as Compared to Survival of Invasive *S. pneumoniae*

Characteristic or Variable	Odds Ratio	Lower CI	Upper CI
		2.5 %	97.5 %
Vaccination Type	0.8802	0.7017	1.0903
Days Hospitalized	1.0064	0.9984	1.0154
Age, years	0.9950	0.9785	1.0107
Type of Infection	1.5841	0.9098	2.9772
Underlying Medical Conditions (Reference No)			
Yes	9.2021*	2.7076	32.0346
Unknown	31.2034*	5.8319	251.6142
Race/Ethnicity	1.1264	0.6889	2.0103

*= Odds Ratio Significant

The results for General Linear Model 4 - Poisson regression, are shown below in Table 3.13. All included variables were found to have an insignificant relationship with patient mortality. The null deviance of General Linear Model 4 – Poisson Regression was 7.3925 on 448 degrees of freedom, while the residual deviance was 7.0741 on 442 degrees of freedom.

Table 3.13 County, Race/Ethnicity and Age Onset Variables Estimated Incidence Rate Ratio of Invasive *S. pneumoniae*

Characteristic or Variable	IRR	Lower CI	Upper CI
		2.5 %	97.5 %
Counties (Reference Sedgwick County)			
Johnson County	1.0374	0.8494	1.2992
Shawnee County	0.9993	0.7796	1.2702
Race/Ethnicity	0.9839	0.8445	1.1355
Age, years	0.9997	0.9957	1.0039

*= Incidence Rate Ratio (IRR) Significant

The results for General Linear Model 5 - Logistic Regression are shown below in Table 3.14. County of residence and underlying medical condition were shown to be significant predictors of the patient's odds of mortality. Residents of Shawnee County were 5.0 times as likely to die from invasive pneumococcal disease than Sedgwick County residents. This model also showed that individuals with underlying medical conditions were 9.0 as likely to die from invasive pneumococcal disease than individuals who did not have an underlying medical condition. While individuals whose status of underlying medical conditions was unknown were 32.1 times as likely to die from pneumococcal disease than individuals with no underlying medical conditions. The null deviance of General Linear Model 5 – Logistic Regression was 301.05 on 448 degrees of freedom, while the residual deviance was 255.65 on 442 degrees of freedom.

Table 3.14 Year, County, Medical Condition, Vaccination Type and Day Hospitalized Variables Associated with Mortality as Compared to Survival of Invasive *S. pneumoniae*

Characteristic or Variable	**Odds Ratio**	**Lower CI**	**Upper CI**
		2.5 %	97.5 %
Year	1.3723*	1.0032	1.8751
Counties (Reference Sedgwick County)			
Johnson County	1.3897	0.5557	3.7281
Shawnee County	6.4841*	2.0411	30.1208
Underlying Medical Condition (Reference No)			
Yes	9.4061*	2.7838	3.2213
Unknown	31.3573*	5.8927	250.2374
Vaccination Type	0.8207	0.6605	1.0313
Number of Days Hospitalized	1.0092	0.9993	1.0202

*= Odds Ratio Significant

The Hosmer-Lemeshow test statistic was 8.1 with a p-value greater than 0.05, meaning that it is not significant and that we are unable to reject the null hypothesis at this time (Table 3.15).

Table 3.15 General Linear Model 5 – Logistic Regression Hosmer and Lemeshow Goodness of Fit Test Results

Hosmer and Lemeshow Goodness of Fit Test		
x^2	Degree of Freedom	P-value
8.1436	8	0.4196

Chapter 4 – Conclusions and Discussions (Falling Action)

Conclusions

The study supports four main assertions, the first being that there are significant differences in case mortality of invasive *S. pnuemoniae* between Sedgwick and Shawnee County. The second claim, being very much related to the first, is that according to the data, Shawnee County had the greatest odds of mortality for individuals infected with invasive *S. pnuemoniae* amongst the three counties.

The third assertion is that having an underlying medical condition decreased individual's odds of surviving invasive *S. pneumoniae*. Individuals whose status for underlying medical conditions was unknown also had greater odds of mortality, but no conclusions can be drawn from this as this category is merely the absences of information and hints that there are still variables that are not entirely accounted for by the available data and models.

The final assertion is that the from this dataset the best predictor of an individual's odds of mortality is a model that accounts for the year the person is infected, their county of residence, the type of vaccine they received and the number of days they are hospitalized for.

Limitations

The main constraint of this study is the limiting study population, in that it only contained a total study population of 445. This population size proved to be unsuitable for more complex statistical models and was the greatest limiting factor for this study.

A second major limitation is that there are currently no valid baseline measurements of what portion of the at-risk population is vaccinated against *S. pneumoniae* for the counties that were included in this study. This in combination with the limited study population made it impossible to accurately assess the current efficacy of the PCV13 and PPSV23 vaccines in the study's population. Another limitation that greatly affected the assessment of the two

recommended vaccines is that there was no serotype data available as to which strain of *S. pneumoniae* the affected individuals were infected with. This, in turn, made it impossible to determine if the recent rise of *S. pneumoniae* cases was a result of decreases efficacy of the vaccines or if Kansas is experiencing another shift in the dominant serotype.

The final limitation is the studies generalizability. Johnson, Sedgwick, and Shawnee Counties were selected for this study because they included 52 percent (445 of 855 cases) of all of the invasive *S. pneumoniae* cases that were reported in the state of Kansas from 2014 to 2017. These counties make up approximately half (44 percent) of the state's total population, but from Table 3.7 we are able to see that there is no significant difference in the study population and Kansas population demographics regarding gender and race/ethnicity. However, the generalizability of this study is greatly hindered by the fact that Johnson, Sedgwick, and Shawnee Counties only represent a total of 2.5 percent of the total land area of Kansas. These three counties have an average population density of 670 people per square mile (259/km^2) while the State of Kansas averages 35 people per square mile (13.5/km^2), as these three counties have the largest metropolitan areas in Kansas. Finally, from Table 3.7 we also see that there were significant differences between the study population and the population of Kansas in every age group. Keeping these facts in mind, it does make it difficult to directly apply the finding of this study to rural counties such as Sherman County, which has a total population of 5,390 and a population density of 6 people per square mile (2.2/km^2).

Future Directions and Recommendations

Even though this study was not able to answer all of the original questions that it set out to, the project will continue as, unfortunately, individuals will continue to be sickened by *S. pneumoniae* and there is no reason to believe that the current trends discussed in this paper will

not continue. This means that the study's population will continue to grow over time, resulting in more available data which may allow for more accurate models and predictions.

As for changes to the overall project, I would strongly recommend that future researchers continue to develop inter- county health department relationships; as one of the largest delays to this project was the sharing of patients' health information between health departments. Additional, further development of these relationships would allow for the inclusion of other counties, such as Wyandotte, Saline, Douglas and Reno Counties. The inclusion of these counties would result in an immediate increase to the study's population, as well as, making the study more generalizable to the entire state of Kansas as a greater portion of the State's population is being represented. Of course, the eventual goal would be to have all reported cases for Kansas of invasive pneumococcal disease to be included in this study, as this would allow for the strongest results possible.

I would also suggest that as the project moves forward, future researchers investigate what the possible differences are in the rate of disease between urban and rural populations. Currently, as the study stands, most of the study population resides in the metropolitan centers of Kansas, as these counties were selected due to having the highest rates of disease and a majority of the reported invasive *S. pnuemoniae* cases. However, approximately one-third of Kansas's total population (9.27×10^5 of 2.91×10^{10}) is classified as living in rural areas and overall have less access to healthcare facilities and lower frequency of social determinants of health than their urban counterparts. Lastly, I would recommend that the serotyping be done for all *S. pneumoniae* patients and be included in all models along with "type of infection" variable. This additional information would confirm if we are seeing a shift in the predominant strain present in the population, which would be subverting the immunity conveyed by the vaccines. Along with this, it is also vital that the included Kansas counties continue to develop accurate vaccination

records for their populations, especially the aging population, as this data will continue to become more important for cross-referencing with the serotype of bacteria strain that they have been infected with to determine each vaccine's current efficacy.

Chapter 5 – Competencies (Resolution)

From first being accepted into this program for the Spring semester of 2017 to the Fall semester 2018, I have completed cores in all five of the areas of core competencies for public health, as well as the five area core competencies of infectious disease and zoonoses; as shown below in Table 5.1.

Table 5.1 Public Health and Infectious Diseases and Zoonoses Areas of Core Competencies

Core Competencies of Public Health		
Areas of Competency	**Course Requirement**	**Term**
1. Biostatistics	MPH 701 – Fundamental Methods of Biostatistics	Spring 2017
2. Environmental Health Sciences	MPH 802 – Environmental Health	Fall 2018
3. Epidemiology	MPH 754 – Introduction to Epidemiology	Fall 2017
4. Health Services Administration	MPH 720 – Administration of Health Care Organizations	Spring 2017
5. Social and Behavioral Sciences	MPH 818 – Social and Behavioral Bases of Public Health	Spring 2018

Core Competencies of Infectious Diseases and Zoonoses		
Areas of Competency	**Course Requirement**	**Term**
1. Pathogens/pathogenic mechanisms	BIOL 530 Pathogenic Microbiology	Fall 2018
	BIOL 675 Genetics of Microorganisms	Fall 2018
2. Host Response to Pathogens/Immunology	BIOL 671 – Immunology Lab	Spring 2018
	DMP 880 – Problems in Pathobiology	Fall 2018
3. Environmental/Ecological Influences	DMP 770 – Emerging Diseases	Summer 2017
4. Disease Surveillance/Quantitative Methods	DMP 854 – Intermediate Epidemiology	Spring 2018
5. Effective Communication	AAI 801 – Interdisciplinary Process	Fall 2018

As this document has outlined, I started my Field Experience at Sedgwick County Division of Health's Epidemiology Program during the Summer of 2018, and it continued through the Fall semester of 2018. I have completed a total of 221.25 hours onsite. During this time, I had worked on the *S. pneumoniae* project covered by this document, participated and observed the day-to-day operations and activities of a fully accredited Public Health Department, received public health and HIPPA training and certifications, as well as assisted with other ongoing projects.

I have identified three main products that I have produced that are a direct result from this field experience. The first product is the *S. pneumoniae* database that had been mentioned earlier in this manuscript and was used for all data analysis and statistical models. The second is this document itself, as well as the accompanying epidemiological report that will be published by Sedgwick County Division of Health in the following months in order to contribute to the comprehensive knowledge of the field of Public Health. The third and final product is an oral presentation that was given at SCDOH, to the entirety of the Epidemiology Program and that will be repeated at the defense of this capstone report. These products are outlined in Table 5.2.

Table 5.2 Summary of Portfolio Products

	Portfolio Product	Description
1.	Disease database of invasive *S. pneumoniae*	A database containing all reported cases of invasive *S. pneumoniae* for Sedgwick and other select Kansas counties.
2.	Capstone and epidemiological report	A written report that contains background, methods, results, discussions, and conclusions coving the entire project with tables, graphs, and appendices to summarize the data and important forms.
3.	Oral presentation	A verbal presentation that utilizes slides that contain background, methods, results, discussions, and conclusions coving the entire project with tables, graphs, and images to summarize the data and important forms.

The next requirement was to select five MPH foundational competencies spanning one or multiple areas of emphasis that I had obtained during the duration of the field experience. The areas of emphasis that I selected included “Evidence-based Approaches to Public Health” and “Interprofessional Practice.” The individual competencies of these two areas are listed in Table 5.3, along with a short description of how each competency was achieved during the field experience.

Table 5.3 Summary of MPH Area of Emphasis Competencies

MPH Area of Emphasis: Evidence-based Approaches to Public Health and Interprofessional Practice		
Number and Competency		**Description**
# 1.	Apply epidemiological methods to the breadth of settings and situations in public health practice	I used current and historical information and data to select factors that may affect an individual's risk of disease (morbidity).
# 2.	Select quantitative and qualitative data collection methods appropriate for a given public health context	I created a database for Sedgwick County and other select counties for possible risk factors and disease outcomes (morality).
# 3.	Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming, and software, as appropriate	I cleaned and performed statistical analysis on the database to determine if any factors had statistical significance on disease outcome.
# 4.	Interpret results of data analysis for public health research, policy or practice	My results and statistical analysis are to be published so that they can be used to create recommendations for policies and practices to protect against future disease.
# 21.	Perform effectively on interprofessional teams	I worked with Sedgwick County's and other select counties epidemiologist to coordinate data and to complete project goals and objectives.

Finally, in Table 5.4, I have matched the portfolio products to the Area of Emphasis Competencies to which they are best suited. The first competency that selected was "Apply epidemiological methods to the breadth of settings and situations in public health practice," and I matched the capstone and epidemiology report to this competency as both of these documents outline the history and how *S. pnuemoniae* causes diseases, which this information was critical for the initial selection of possible risk factors when first creating the *S. pnuemoniae* case database.

For the second competency of "Select quantitative and qualitative data collection methods appropriate for a given public health context," I matched the invasive *S. pnuemoniae* case databases, as the database was a collection of qualitative and quantitative factors that had been reported from patients that had been infected with invasive *S. pnuemoniae*. I believe the ability to produce such a database, that is still in use, speaks to my ability to select and utilize appropriate data collection methods.

For the third and fourth competences, "Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming, and software, as appropriate" and

"Interpret results of data analysis for public health research, policy or practice" respectively, I matched both the capstone and epidemiology report and oral presentation to both of them, as both of these products focus on the use of computer programs and software to run statistical models for the purpose of furthering our understanding of what has contributed to the recent trends of pneumococcal disease and if steps could be taken to limit the future impact of disease.

The fifth and final competency was to "perform effectively on interprofessional teams." I believe that all of the listed products, and more than that the entire project, supports the mastery of this competency. Before the project even started, multiple public health departments across three different counties needed to be coordinated to release the appropriate information and to continue to receive updates as new data became available, as well as contacting dozens of personal health care providers for information that was relevant to the study, but was absent from the initial disease report. Once the data was collected, the collaborations continued, as we had to determine what the most important questions were, with input from all involved parties, and what the best models were to answer them.

Table 5.4 Portfolio Products and Competency Addressed

Portfolio Product		Number and Competency Addressed	
2.	Capstone and Epidemiological Report	# 1.	Apply epidemiological methods to the breadth of settings and situations in public health practice
1.	Disease Database of Invasive S. pneumoniae	# 2.	Select quantitative and qualitative data collection methods appropriate for a given public health context
2. & 3.	- Capstone and Epidemiological Report - Oral Presentation	# 3.	Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate
2. & 3.	- Capstone and Epidemiological Report - Oral Presentation	# 4.	Interpret results of data analysis for public health research, policy or practice
1., 2. & 3.	All Portfolio Products Listed	# 21.	Perform effectively on interprofessional teams

I believe that I have made a well-found case that I have achieved mastery of all the list competencies and that the listed products were worth the time and effort that was necessary to

create them. It is my sincere hope that these will help to advance understanding of pneumococcal diseases and improve practices so that we can limit the suffering caused by this and similar agents.

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Appendix A – KDHE, *Streptococcus pneumoniae*, Invasive Disease Investigation Guideline

Kansas
Department of Health and Environment
Division of Health

Streptococcus pneumoniae, Invasive Disease Investigation Guideline

Contents

Attachments can be accessed through the Adobe Reader's navigation panel for attachments. Throughout this document attachment links are indicated by this symbol ; when the link is activated in Adobe Reader it will open the attachments navigation panel. The link may not work when using PDF readers other than Standard Adobe Reader.

Effective Date: 01/2010
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Revision History:

Date	Replaced	Comments
05/2018	**12/2014**	Updated Invasive Pneumococcal Disease case definition. Notification Section modified with requirements of revised regulations.
12/2014	**11/2010**	Reformatted Standard Case Investigation and Data Management section to assist with EpiTrax system data entry. Added a Notification section. Updated web links, including link to the most current CDC recommendation for the use of pneumococcal vaccine. Reformatted fact sheet.
11/2010	**01/2010**	Removal of clinically compatible from the listed case definition to bring it into agreement with CDC guidance. (In 02/2012, removed references to KS-EDSS.)

Streptococcus pneumoniae, Invasive Disease
Disease Management and Investigative Guidelines

CASE DEFINITION (CDC 2017) – Invasive Pneumococcal Disease (IPD) (Streptococcus pneumoniae)

Clinical Description for Public Health Surveillance:
Invasive Pneumococcal *(Streptococcus pneumoniae*) Disease or IPD causes many clinical syndromes, depending on the site of infection (e.g., bacteremia, meningitis.)

Laboratory Criteria for Case Classification:
Supportive: Identification of *S. pneumoniae* from a normally sterile body site by a CIDT without isolation of the bacteria.

Confirmatory: Isolation of *S. pneumoniae* from a normally sterile body site.

Criteria to Distinguish a New Case from Existing Case: A single case should be defined as a health event with a specimen collection date that occurs more than 30 days from the last known specimen with a positive lab finding.

Case Classification:
- **Probable:** **A case that meets the supportive laboratory evidence.**
- **Confirmed:** **A case that meets the confirmatory laboratory evidence.**

Comments: The use of CIDTs as stand-alone tests for the direct detection of *S. pneumoniae* from clinical specimens is increasing. Data regarding their performance indicate variability in the sensitivity, specificity, and positive predictive value of these assays depending on the manufacturer and validations methods used. It is therefore useful to collect information on the laboratory conducting the testing, and the type and manufacturer of the CIDT used to diagnose each IPD case. Culture confirmation of CIDT-positive specimens is still the ideal method of confirming a case of IPD.

CASE DEFINITION (CDC 2007) – Streptococcus pneumoniae, Drug-Resistant Invasive Disease (DRSP) *[Used for all ages.]*

Clinical Description for Public Health Surveillance
Same as above for invasive *Streptococcus pneumoniae*.

Laboratory Criteria for Case Classification:
- Isolation of *S. pneumoniae* from a normally sterile site (e.g., blood, cerebrospinal fluid, or, less commonly, joint, pleural, or pericardial fluid) and
- "Nonsusceptible" isolate (i.e., intermediate- or high-level resistance* of the S. pneumoniae isolate to at least one antimicrobial agent currently approved for use in treating pneumococcal infection.)

* Resistance defined by National Committee for Clinical Laboratory Standards (NCCLS)-approved methods and NCCLS-approved interpretive minimum inhibitory concentration (MIC) standards (µg/ml) for *S. pneumoniae*.

Case Classification:
- **Confirmed:** Case that is laboratory-confirmed.
- **Probable:** Case caused by laboratory-confirmed culture of *S. pneumoniae* identified as "nonsusceptible" (i.e., an oxacillin zone size of less than 20 mm) when oxacillin screening is the only method of antimicrobial susceptibility testing performed.

LABORATORY ANALYSIS

- Gram stains and cultures are performed routinely by commercial laboratories.
- Submission of ***invasive*** *S. pneumoniae* isolates to the Kansas Health and Environmental Laboratory (KHEL*) is* <u>*required by law*</u>. (K.A.R. 28-1-18)
- Shipping of isolates: Use Miscellaneous Infectious Disease (IDS) Shipper.
- For additional information and/or questions concerning isolate submission call (785) 296-1620.

EPIDEMIOLOGY

S. pneumoniae is a leading cause worldwide of illness and death for young children, persons with underlying medical conditions, and the elderly. It is the most commonly identified cause of bacterial pneumonia; and, since the widespread use of vaccines against *Haemophilus influenzae* type b, it has become the most common cause of bacterial meningitis in the United States. Rates of invasive disease are highest among persons younger than 2 years of age and those 65 years of age or older. Pneumococci are in the upper respiratory tract of 15% of well adults; in child care settings, up to 65% of children are colonized. Although pneumococcal carriage can lead to invasive disease, acute otitis media (AOM) is the most common clinical manifestation among children and the most common outpatient diagnosis resulting in antibiotic prescriptions in that group. Approximately 12% of all patients with invasive pneumococcal disease die of their illness, but case-fatality rates are higher for the elderly and patients with certain underlying illnesses.

Before 1990, S. pneumoniae was almost uniformly susceptible to penicillin, allowing most physicians to treat persons with severe infections with penicillin alone. However, during the 1990s, resistance to penicillin and to multiple classes of antimicrobial agents spread rapidly in the United States, with an increasing trend of invasive pneumococci resistant to three or more drug classes. In 1998, 24% of invasive pneumococcal isolates were non-susceptible to penicillin, and 78% of these strains belonged to five of the seven serotypes included in PCV7, a 7-valent pneumococcal polysaccharide–protein conjugate vaccine. Following the introduction of PCV7 into the routine childhood immunization program in 2000, the incidence of antibiotic-resistant invasive disease declined substantially. In 2004, the rate of penicillin- non-susceptible invasive disease caused by serotypes included in PCV7 had declined by 98% among children younger than 2 years of age and by 79% among adults 65 years or older. In contrast, there was an increase in penicillin-resistant disease caused by serotypes not included in PCV7, but the magnitude of this effect remains small.

DISEASE OVERVIEW

A. Agent:
S. pneumoniae, Gram positive diplococcus. Nearly all strains causing invasive disease are encapsulated; there are 90 known capsular serotypes

B. Clinical Description:
Several invasive clinical syndromes, including pneumonia, bacteremia and meningitis. *S. pneumoniae* is also a cause of AOM and mastoiditis.**Reservoirs:**
Humans.

C. Mode(s) of Transmission:
S. pneumoniae are transmitted person-to-person by large droplet spread and/or by contact with respiratory secretions. Casual contact can result in nasopharyngeal carriage of the organism without illness developing. Individuals with acute respiratory tract infections (particularly nasal) can transmit noninvasive infection (i.e. upper respiratory infections). Invasive disease is not transmitted person-to-person as it only occurs after the bacteria get past the immune defenses of a person who is infected or colonized.

D. Incubation Period:
Unknown, probably short, 1-4 days.

E. Period of Communicability:
As long as organism is present in respiratory secretions; a person is regarded as noninfectious 24-48 hours after appropriate antibiotic treatment begins.

F. Susceptibility and Resistance:
Immunity associated with circulating bactericidal and /or anticapsular antibody, acquired transplacentally or from prior infection or immunization.

G. Treatment:
Penicillin, ceftriaxone, or cefotaxime are drugs of choice. When resistance is widespread, treatment will usually include a broad-spectrum cephalosporin, and often vancomycin, until results of antibiotic sensitivity testing are available.

NOTIFICATION TO PUBLIC HEALTH AUTHORITIES

Suspected cases of invasive *Strep. pneumoniae* shall be reported within 24 hours, except if the reporting period ends on a weekend or state-approved holiday, the report shall be made by 5:00 p.m. on the next business day after the 24-hour period.

1. Health care providers and hospitals: report to local health jurisdiction
2. Laboratories: report to KDHE - BEPHI
3. Local health jurisdiction: report to KDHE - BEPHI

Kansas Department of Health and Environment (KDHE)
Bureau of Epidemiology and Public Health Response (BEPHI)
Phone: 1-877-427-7317
Fax: 1-877-427-7318

Further responsibilities of state and local health departments to the CDC:
As a nationally notifiable condition, Streptococcus pneumoniae, invasive disease (IPD) cases require a ROUTINELY NOTIFIABLE report to the Center of Disease Control and Prevention (CDC).

1. Routine reporting requires KDHE-BEPHI to file an electronic report for within the next reporting cycle.
   - KDHE-BEPHI will file electronic reports weekly with CDC.
2. **Local public health jurisdiction** will report information requested in the Kansas electronic surveillance system, as soon as possible, ensuring that the electronic form is completed within 7 days of receiving a notification of a report.

INVESTIGATOR RESPONSIBILITIES

1) Report all confirmed, probable and suspect cases to the KDHE.

2) Begin the public health investigation within 3 days of receiving a report; completing the investigation within 7 days.

3) The goal of the case investigation is to collect epidemiological data as required by current surveillance objectives.
   - Contact the medical provider to collect additional information and confirm diagnosis using the current case definition.
   - Collect all information requested in Step 1) of case investigation.
   - Most data can be collected from the medical provider, and the patient will not need to be contacted.
   - Routine contact investigation and/or an investigation for a source is of no practical value for *S. pneumoniae* cases.

4) Ensure invasive *S. pneumoniae* isolates were sent to the state laboratory.

5) Record data, collected during the investigation, in the KS EpiTrax system under the data's associated [tab] in the case morbidity report (CMR).

6) As appropriate, use the disease fact sheet to notify individuals or groups.

STANDARD CASE INVESTIGATION AND CONTROL METHODS

Case Investigation

1) Contact the medical provider who reported or ordered testing of the case to obtain the following from the patient's medical records.
   For all cases, the following data is ESSENTIAL:
   - ***Demographic data (birth date, county, sex, race/ethnicity)*** [Demographic]
   - ***Anatomic site from which organism is isolated*** [Laboratory]
   - ***Type of infection*** [Investigation-Symptoms]
   - **Antibiotic susceptibility** – scanned and attach to CMR [Notes-Add Attachment]

   Additional information to collect for cases includes:
   - Onset date of illness [Clinical];
   - Attendance at a daycare facility: include name of facility [Epidemiological];
   - Hospitalizations: location and duration of stay [Clinical];
   - Outcomes: survived and date of recovery or date of death [Clinical];
   - Underlying medical conditions prior to illness [Investigation-Complications];
   - Date first positive culture obtained [Laboratory]; and
   - Through a credible immunization registry or medical record information on pneumococcal vaccination(s), including date(s) of vaccination, vaccine name, manufacturer, lot number [Investigation-Vaccination History]
2) If there is no indication that the isolate has been sent to KHEL, call or send a reminder to the laboratory that performed the testing that they are required by law to submit all invasive *S. pneumoniae* isolates to the state laboratory.
3) Investigate any epi-links among cases (cluster, household, co-workers, etc) if identified. For suspected outbreaks refer to Managing Special Situations.

Contact Investigation

Contact investigation is of no practical value for routine situations.

Isolation, Work and Daycare Restrictions

Hospitalized patients: Standard precautions are recommended, including patients with infections caused by drug-resistant *S. pneumoniae*.

Case Management

Report on any changes in patient status (i.e. date of death). [Clinical]

Contact Management

None required.

Environmental Measures

In day care settings, the regularly cleaning of toys with an approved disinfectant is recommended. For more information on *S. pneumoniae* in daycares, refer to Managing Special Situations.

Education

If contacts or household members inquire about their risk of acquiring the disease:

- Use the *S. pneumoniae* fact sheet to answer inquiries.
- Stress the following:
  - Invasive disease is not spread person-to-person;
  - Antibiotic treatment is not an effective way of protecting contacts exposed to a meningitis caused by bacteria, other than *N. meningitidis* or *H. influenzae* type B; but
  - Medical attention should be sought immediately if they do begin to exhibit signs and symptoms of severe illness.
- Instruct household members or close contacts to:
  - Practice basic hygiene emphasizing proper hand washing technique.
  - Avoid sharing food, beverages, cigarettes or eating utensils.
- Those at high risk or presumed high risk of acquiring invasive pneumococcal infection (i.e., immunocompromised, sickle cell disease, or functional or anatomic asplenia) should be directed to discuss current health status (including immunization history) with their primary care physician and/or routine immunization provider.
  - The local health department should strive to make sure those in the groups recommended for immunization have access the vaccine.
  - Current recommendations for pneumococcal vaccine usage can be found at www.cdc.gov/vaccines/vpd-vac/pneumo/default.htm

MANAGING SPECIAL SITUATIONS

A. Outbreak Investigation:

1. Consider further investigation of any invasive cases clustered in time and place among groups that share common space (i.e. daycare, institutions)
2. Notify KDHE immediately, 1-877-427-7317.
3. Case finding and additional case investigation will be an important part of any investigation.

B. Daycares and *Streptococcus pneumoniae*

- Out-of-home day care increases the risk for invasive pneumococcal disease and AOM among children. Day care attendance is also a risk factor for other acute upper respiratory tract infections among children aged <5 years. (Source: www.cdc.gov/mmwr/preview/mmwrhtml/rr4909a1.htm)
- Children aged 24--59 months who attend group daycares (defined by any setting outside a home where a child regularly spends >4 hours/week with >2 unrelated children under adult supervision) were considered part of a priority group that the ACIP recommends receive PCV7 vaccination.
- Reference K.A.R. 28-1-20 for current immunization requirements for daycares; on-line at: www.kdheks.gov/immunize/schoolInfo.htm

DATA MANAGEMENT AND REPORTING TO THE KDHE

A. Accept the case assigned to the LHD and record the date the LHD investigation was started on the [Administrative] tab.

B. Organize and collect data.
- The *Streptococcus pneumoniae* Surveillance Worksheet is provided to assist the investigator but does not have to be submitted to CDC or KDHE.
- Investigators can collect and enter all required information directly into EpiTrax [Investigation], [Clinical], [Demographics], and [Epidemiological] tabs without using the paper forms.
- During outbreak investigations, refer to guidance from a KDHE epidemiologist for appropriate collection tools.

C. Report data collected during the investigation via EpiTrax**.**
- Verify that all data requested in Step 1) has been recorded on an appropriate EpiTrax [tab], or that actions are completed for a case lost to follow-up as outlined below.
- Some data that cannot be reported on an EpiTrax [tab] may need to be recorded in [Notes] or scanned and attached to the record.
- Paper report forms do not need to be sent to KDHE after the information is recorded in EpiTrax. The forms should be handled as directed by local administrative practices.

D. If a case is lost to follow-up, after the appropriate attempts:
- Indicate 'lost to follow-up' on the [Administration] tab with the number of attempts to contact the case recorded.
- Record at least the information that was collected from the medical records.
- Record a reason for 'lost to follow-up' in [Notes].

E. After the requirements listed under Case Investigation have been completed, record the "Date LHD investigation completed" field located on the [Administrative] tab.
- Record the date even if the local investigator's Case or Contact Management for the contact is not "Complete".

F. Once the entire investigation is completed, the LHD investigator will click the "Complete" button on the [Administrative] tab. This will trigger an alert to the LHD Administrator so they can review the case before sending to the state.
- The LHD Administrator will then "Approve" or "Reject" the CMR.
- Once a case is "Approved" by the LHD Administrator, BEPHI staff will review the case to ensure completion before closing the case.

G. Review the EpiTrax User Guide, Case Routing for further guidance.

Reporting to CDC for Children, < 5years
Since 2007, a case definition and a separate event code is available for reporting of pneumococcal disease (non-drug resistant) for children <5 years.
- Isolates causing IPD from children less than five years of age for which antibacterial susceptibilities are available and determined to be DRSP should be reported only as DRSP (event code 11720).
- Isolates causing IPD from children less than five years of age which are susceptible, or for which susceptibilities are not available should be reported ONLY as IPD in children less than five years of age (event code 11717).

ADDITIONAL INFORMATION / REFERENCES

A. **Treatment / Differential Diagnosis:** American Academy of Pediatrics. Red Book: Report of the Committee on Infectious Disease, 29th Edition. Illinois, Academy of Pediatrics, 2014.

B. **Epidemiology, Investigation and Control:** Heymann. D., ed., Control of Communicable Diseases Manual, Washington, DC, American Public Health Association, 2010.

C. **Case Definitions:** wwwn.cdc.gov/nndss/

D. **Kansas Regulations/Statutes Related to Infectious Disease:** www.kdheks.gov/epi/regulations.htm

E. **Pink Book:** Epidemiology and Prevention of Vaccine-Preventable Diseases. Available at: www.cdc.gov/vaccines/pubs/pinkbook/index.html

F. **Manual for the Surveillance of Vaccine-Preventable Diseases:** Available at: www.cdc.gov/vaccines/pubs/surv-manual/index.html .

G. **Preventing Pneumococcal Disease Among Infants and Young Children; Recommendations of the Advisory Committee on Immunization Practices (ACIP).** MMWR December 9, 2005 / 54(RR14); 1-16. Available at: www.cdc.gov/mmwr/preview/mmwrhtml/rr4909a1.htm

H. **Additional Information (CDC):** www.cdc.gov/vaccines/pubs/surv-manual/index.html

ATTACHMENTS

To view attachments in the electronic version:

1. Go to <View>; <Navigation Pane>; <Attachments> – OR – Click on the "Paper Clip" icon at the left.
2. Double click on the document to open.

Streptococcus pneumoniae Surveillance Worksheet

NAME (Last, First)				Hospital Record No.
Address (Street and No.)	City	County	Zip	Phone
Reporting Physician/Nurse/Hospital/Clinic/LabPhone	Address			Phone

DETACH HERE and transmit only lower portion if sent to CDC

Streptococcus pneumoniae Surveillance Worksheet

(Invasive pneumococcal disease and drug-resistant *S. pneumoniae*)

THROUGHOUT: Y=YES N=NO U=UNKNOWN

1. Are you reporting:
   - Drug Resistant *S. pneumoniae* Y ☐ N ☐ U ☐
   - Invasive Disease Y ☐ N ☐ U ☐
2. Date of Birth ☐☐-☐☐-☐☐☐☐ (MONTH DAY YEAR)
3a. Age ☐☐☐
3b. Is age in years / months / weeks / days?
   ☐ years ☐ months ☐ weeks ☐ days
4. Sex ☐ Male ☐ Female ☐ Unknown
5. Race: *(check all that apply)*
   - ☐ American Indian / Alaska native
   - ☐ Asian
   - ☐ Black or African American
   - ☐ Native Hawaiian or Pacific Islander
   - ☐ White
   - ☐ Other race (specify) _____
6. Ethnicity: is patient Hispanic or Latino? Y ☐ N ☐ U ☐
7. State in which patient resided at time of diagnosis: ☐☐
8. Zip code at which patient resided at time of diagnosis: ☐☐☐☐☐
9a. Hospitalized? Y ☐ N ☐ U ☐
9b. If hospitalized for this condition, how many days total was the patient hospitalized? *(Include days from multiple hospitals if relevant)*
   ☐☐☐ NUMBER OF DAYS: 0-998; 999=UNKNOWN
10. Does this patient: *(check all that apply)*
   - Attend a day care* facility? Y ☐ N ☐ U ☐
     Facility Name _____
     *DAY CARE IS DEFINED AS AS SUPERVISED GROUP OF 2 OR MORE UNRELATED CHILDREN FOR >4 HOURS PER WEEK.
   - Reside in a long term care facility? Y ☐ N ☐ U ☐
     Facility Name _____
11. Did patient die from this illness? Y ☐ N ☐ U ☐
12. Onset Date ☐☐-☐☐-☐☐☐☐ (MONTH DAY YEAR)
13. Type of infection caused by organism *(check all that apply)*
   - Bacteremia without focus ☐
   - Cellulitis ☐
   - Epiglottitis ☐
   - Hemolytic uremic syndrome ☐
   - Meningitis ☐
   - Osteomyelitis ☐
   - Otitis media ☐
   - Peritonitis ☐
   - Pericarditis ☐
   - Pneumonia ☐
   - Septic arthritis ☐
   - Other *(specify)* _____ ☐
14. Sterile site from which organism isolated: *(check all that apply)*
   - Blood ☐
   - CSF ☐
   - Pleural fluid ☐
   - Peritoneal fluid ☐
   - Pericardial fluid ☐
   - Joint ☐
   - Bone ☐
   - Internal body site ☐
   - Muscle ☐
   - Other normally sterile site ☐
     (specify) _____
15. Date first positive culture obtained
   DATE SPECIMIN TAKEN ☐☐-☐☐-☐☐☐☐ (MONTH DAY YEAR)
16. Nonsterile sites from which organism isolated, if any:
   Middle ear ☐ Sinus ☐ Other *(specify)* _____ ☐
17a. Does the patient have any underlying medical conditions or prior illness?
   - Y ☐ Yes. If yes fill out 17b.
   - N ☐ No. If no skip to 18.
   - U ☐ Unknown. Skip to 18.
17b. What underlying medical conditions does the patient have? *(check all that apply)*
   - Current smoker ☐
   - Multiple myeloma ☐
   - Sickle cell anemia ☐
   - Splenectomy / asplenia ☐
   - Immunoglobulin deficiency ☐
   - Immunosuppressive therapy (steroids, chemotherapy, radiation) ☐
   - Leukemia ☐
   - Hodgkin's disease ☐
   - Asthma ☐
   - Emphysema / COPD ☐
   - Systemic lupus erythematosus ☐
   - Diabetes mellitus ☐
   - Nephrotic syndrome ☐
   - Renal failure / dialysis ☐
   - HIV infection ☐

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AIDS (CD4 <200)	☐	CSF leak	☐
Cirrhosis / liver failure	☐	Intraveinous drug use	☐
Alcohol abuse	☐	Other malignancy *(specify)* _____	☐
Cardiovascular disease (ASCVD) / CAD	☐	Organ / bone marrow transplant	☐
Heart failure / CHF	☐	Other prior illness *(specify)* _____	☐

VACCINATION HISTORY

18. Did patient receive **POLYSACCHARIDE** pneumococcal vaccine? Y ☐ N ☐ U ☐ If **YES**, please complete the list below.

DOSE	DATE GIVEN (MONTH/DAY/YEAR)	VACCINE NAME	LOT NUMBER
1	☐☐-☐☐-☐☐☐☐	☐ Pneumovax 23 (Merck) ☐ Pnu-Imune23 (Wyeth) Other_____	
2	☐☐-☐☐-☐☐☐☐	☐ Pneumovax 23 (Merck) ☐ Pnu-Imune23 (Wyeth) Other_____	
3	☐☐-☐☐-☐☐☐☐	☐ Pneumovax 23 (Merck) ☐ Pnu-Imune23 (Wyeth) Other_____	

19. Did patient receive **CONJUGATE** pneumococcal vaccine? Y ☐ N ☐ U ☐ If **YES**, please complete the list below.

DOSE	DATE GIVEN (MONTH/DAY/YEAR)	VACCINE NAME	MANUFACTURER	LOT NUMBER
1	☐☐-☐☐-☐☐☐☐			
2	☐☐-☐☐-☐☐☐☐			
3	☐☐-☐☐-☐☐☐☐			
4	☐☐-☐☐-☐☐☐☐			

20. Resistance Testing Results

Oxacillin zone size: ☐☐mm **Oxacillin interpretation:** ☐R < 20mm (possibly resistant) ☐S ≥20mm (susceptible) ☐Unknown/not tested
(valid 00-30)

SUSCEPTIBILITY METHOD CODES	S/I/R RESULT CODES	SIGN CODES	MIC VALUE
A- AGAR: Agar dilution method **B-** BROTH: Broth dilution **C-** DISK: Disk diffusion (Kirby Bauer) **S-** STRIP: Antimicrobial gradient strip (E-test)	**S-** SUSCEPTIBLE **B-** INTERMEDIATE **C-** RESISTANT **S-** UNK. / NOT TESTED Result indicates whether the microorganism is susceptible or not susceptible (intetrmediate or resistant) to the antimicrobial being tested	Indicate whether the MIC is <, >, ≤, ≥, = to the numerical MIC value in the last column	Valid range for data value 0.000 - 999.999
		MIC = minimum inhibitory concentration	

21.

ANTIMICROBIAL AGENT	SUSCEPTIBILITY METHOD A/B/D/S	S/I/R/U RESULT	SIGN < / > / ≤ / ≥ / =	MIC VALUE (e.g., 0.06 µg/ml)
Penicilin				
Amoxicillin				
Amoxicillin/clavulanic acid				
Cefotaxime				
Ceftriaxone				
Cefuroxime				
Vancomycin				
Erythromycin				
Azithromycin				
Tetracycline				
Levofloxacin				
Sparfloxacin				
Gatifloxacin				
Moxifloxacinn				
Trimethoprim/sulfamethoxazole				
Clindamycin				
Quinupristin/dalfopristin				
Linazolid				
Other: (list)				

Submitted by:_____ Phone (_____)_____ Date: ☐☐-☐☐-☐☐☐☐
MONTH DAY YEAR

Appendix B – KDHE, Pneumococcal Disease Fact Sheet

Pneumococcal Disease Fact Sheet

What is pneumococcal disease?
Pneumococcal disease is defined as infections that are caused by the bacteria *Streptococcus pneumoniae*, also known as pneumococcus. The most common types of infections caused by this bacterium include middle ear infections, pneumonia, blood stream infections (bacteremia), sinus infections, and meningitis.

Who is more likely to get pneumococcal disease?
Young children are much more likely than older children and adults to get pneumococcal disease. Children less than 2 years of age, children in group child care, and children who have certain illnesses (for example sickle cell disease, HIV infection and chronic heart or lung conditions) are at higher risk than other children to get pneumococcal disease. In addition, pneumococcal disease is more common among children of certain racial or ethnic groups, such as Alaska Natives, Native Americans, and African-Americans, than among other groups.

What are the symptoms of pneumococcal disease?

- **Meningitis:** High fever, headache, and stiff neck are common symptoms of meningitis in anyone over 2 years age. These symptoms can develop over several hours or may take 1 to 2 days. Other symptoms may include nausea, vomiting, discomfort looking into bright lights, confusion, and sleepiness. In newborns and small infants, the classic symptoms of fever, headache, and neck stiffness may be absent or difficult to detect, and the infant may only appear slow or inactive, or be irritable, have vomiting, or be feeding poorly.
- **Pneumonia:** In adults, pneumococcal pneumonia is often characterized by sudden onset of illness with symptoms of shaking chills, fever, shortness of breath or rapid breathing, pain in the chest that is worsened by breathing deeply, and a productive cough. In infants and young children, signs and symptoms may not be specific, and may include fever, cough, rapid breathing or grunting.
- **Otitis media:** Children who have otitis media (middle ear infection) typically have a painful ear, and the eardrum is often red and swollen. Other symptoms that may accompany otitis media include sleeplessness, fever and irritability.
- **Blood stream infections (bacteremia):** Infants and young children with blood stream infections typically have non-specific symptoms including fevers and irritability.

How serious is pneumococcal disease?
Pneumococcal disease is a very serious illness in young children. Pneumococcal infections are now the most common cause of invasive bacterial infection in U. S. children. In the United States it is estimated that pneumococcal infections cause 100 deaths, 450 cases of meningitis, 4,000 cases of bacteremia or other invasive disease, and 3.1 million cases of otitis media (ear infections) annually in children under 5 years of age.

Meningitis is the most severe type of pneumococcal disease. Of children less than 5 years of age with pneumococcal meningitis, about 5% will die of their infection and others may have long-term problems such as hearing loss. Many children with pneumococcal pneumonia or blood stream infections will be ill enough to be hospitalized; about 1% of children with blood stream infections or pneumonia with a blood stream infection will die of their illness. Nearly all children with ear infections recover, although children with recurrent infections can suffer hearing loss.

How is pneumococcal disease spread?
The bacteria are spread through contact between persons who are ill or who carry the bacteria in their throat. Transmission is mostly through the spread of respiratory droplets from the nose or mouth of a person with a pneumococcal infection. It is common for people, especially children, to carry the bacteria in their throats without being ill from it.

How is pneumococcal disease treated or cured?
Pneumococcal disease is treated with antibiotics. Over the last decade, many pneumococci have become resistant to some of the antibiotics used to treat pneumococcal infections; high levels of resistance to penicillin are common.

Can pneumococcal disease in children be prevented?

Two different vaccines are used to prevent pneumococcal disease. The pneumococcal conjugate vaccine (PCV13) is given to children in the first two years of life and to certain adults with conditions that weaken their immune system. The pneumococcal polysaccharide vaccine (PPSV23) is given to adults 65 years of age and older, as well as children and younger adults with certain high-risk conditions.

Where can I get more information?
www.cdc.gov/pneumococcal/index.html

This fact sheet is for information only and is not intended for self-diagnosis or as a substitute for consultation. If you have any questions about the disease described above or think that you may have an infection, consult with your healthcare provider.

Version 12/2014

Appendix C – CDC, Vaccine Information Statement: Pneumococcal Conjugate Vaccine (PCV13)

VACCINE INFORMATION STATEMENT

Pneumococcal Conjugate Vaccine (PCV13)

What You Need to Know

Many Vaccine Information Statements are available in Spanish and other languages. See www.immunize.org/vis

Hojas de información sobre vacunas están disponibles en español y en muchos otros idiomas. Visite www.immunize.org/vis

1 Why get vaccinated?

Vaccination can protect both children and adults from **pneumococcal disease**.

Pneumococcal disease is caused by bacteria that can spread from person to person through close contact. It can cause ear infections, and it can also lead to more serious infections of the:

- Lungs (pneumonia),
- Blood (bacteremia), and
- Covering of the brain and spinal cord (meningitis).

Pneumococcal pneumonia is most common among adults. Pneumococcal meningitis can cause deafness and brain damage, and it kills about 1 child in 10 who get it.

Anyone can get pneumococcal disease, but children under 2 years of age and adults 65 years and older, people with certain medical conditions, and cigarette smokers are at the highest risk.

Before there was a vaccine, the United States saw:

- more than 700 cases of meningitis,
- about 13,000 blood infections,
- about 5 million ear infections, and
- about 200 deaths

in children under 5 each year from pneumococcal disease. Since vaccine became available, severe pneumococcal disease in these children has fallen by 88%.

About 18,000 older adults die of pneumococcal disease each year in the United States.

Treatment of pneumococcal infections with penicillin and other drugs is not as effective as it used to be, because some strains of the disease have become resistant to these drugs. This makes prevention of the disease, through vaccination, even more important.

2 PCV13 vaccine

Pneumococcal conjugate vaccine (called PCV13) protects against 13 types of pneumococcal bacteria.

PCV13 is routinely given to children at 2, 4, 6, and 12–15 months of age. It is also recommended for children and adults 2 to 64 years of age with certain health conditions, and for all adults 65 years of age and older. Your doctor can give you details.

3 Some people should not get this vaccine

Anyone who has ever had a life-threatening allergic reaction to a dose of this vaccine, to an earlier pneumococcal vaccine called PCV7, or to any vaccine containing diphtheria toxoid (for example, DTaP), should not get PCV13.

Anyone with a severe allergy to any component of PCV13 should not get the vaccine. *Tell your doctor if the person being vaccinated has any severe allergies.*

If the person scheduled for vaccination is not feeling well, your healthcare provider might decide to reschedule the shot on another day.

4 Risks of a vaccine reaction

With any medicine, including vaccines, there is a chance of reactions. These are usually mild and go away on their own, but serious reactions are also possible.

Problems reported following PCV13 varied by age and dose in the series. The most common problems reported among children were:

- About half became drowsy after the shot, had a temporary loss of appetite, or had redness or tenderness where the shot was given.
- About 1 out of 3 had swelling where the shot was given.
- About 1 out of 3 had a mild fever, and about 1 in 20 had a fever over 102.2°F.
- Up to about 8 out of 10 became fussy or irritable.

Adults have reported pain, redness, and swelling where the shot was given; also mild fever, fatigue, headache, chills, or muscle pain.

Young children who get PCV13 along with inactivated flu vaccine at the same time may be at increased risk for seizures caused by fever. Ask your doctor for more information.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Problems that could happen after any vaccine:

- People sometimes faint after a medical procedure, including vaccination. Sitting or lying down for about 15 minutes can help prevent fainting, and injuries caused by a fall. Tell your doctor if you feel dizzy, or have vision changes or ringing in the ears.
- Some older children and adults get severe pain in the shoulder and have difficulty moving the arm where a shot was given. This happens very rarely.
- Any medication can cause a severe allergic reaction. Such reactions from a vaccine are very rare, estimated at about 1 in a million doses, and would happen within a few minutes to a few hours after the vaccination.

As with any medicine, there is a very small chance of a vaccine causing a serious injury or death.

The safety of vaccines is always being monitored. For more information, visit: **www.cdc.gov/vaccinesafety/**

5 What if there is a serious reaction?

What should I look for?

- Look for anything that concerns you, such as signs of a severe allergic reaction, very high fever, or unusual behavior.

  Signs of a severe allergic reaction can include hives, swelling of the face and throat, difficulty breathing, a fast heartbeat, dizziness, and weakness—usually within a few minutes to a few hours after the vaccination.

What should I do?

- If you think it is a severe allergic reaction or other emergency that can't wait, call 9-1-1 or get the person to the nearest hospital. Otherwise, call your doctor.

  Reactions should be reported to the Vaccine Adverse Event Reporting System (VAERS). Your doctor should file this report, or you can do it yourself through the VAERS web site at **www.vaers.hhs.gov**, or by calling **1-800-822-7967**.

VAERS does not give medical advice.

6 The National Vaccine Injury Compensation Program

The National Vaccine Injury Compensation Program (VICP) is a federal program that was created to compensate people who may have been injured by certain vaccines.

Persons who believe they may have been injured by a vaccine can learn about the program and about filing a claim by calling **1-800-338-2382** or visiting the VICP website at **www.hrsa.gov/vaccinecompensation**. There is a time limit to file a claim for compensation.

7 How can I learn more?

- Ask your healthcare provider. He or she can give you the vaccine package insert or suggest other sources of information.
- Call your local or state health department.
- Contact the Centers for Disease Control and Prevention (CDC):
  - Call **1-800-232-4636** (**1-800-CDC-INFO**) or
  - Visit CDC's website at **www.cdc.gov/vaccines**

Vaccine Information Statement

PCV13 Vaccine

11/05/2015

42 U.S.C. § 300aa-26

Office Use Only

Appendix D – CDC, Vaccine Information Statement: Pneumococcal Polysaccharide Vaccine (PPSV23)

VACCINE INFORMATION STATEMENT

Pneumococcal Polysaccharide Vaccine

What You Need to Know

Many Vaccine Information Statements are available in Spanish and other languages. See www.immunize.org/vis

Hojas de información sobre vacunas están disponibles en español y en muchos otros idiomas. Visite www.immunize.org/vis

1 Why get vaccinated?

Vaccination can protect older adults (and some children and younger adults) from **pneumococcal disease**.

Pneumococcal disease is caused by bacteria that can spread from person to person through close contact. It can cause ear infections, and it can also lead to more serious infections of the:

- Lungs (pneumonia),
- Blood (bacteremia), and
- Covering of the brain and spinal cord (meningitis). Meningitis can cause deafness and brain damage, and it can be fatal.

Anyone can get pneumococcal disease, but children under 2 years of age, people with certain medical conditions, adults over 65 years of age, and cigarette smokers are at the highest risk.

About 18,000 older adults die each year from pneumococcal disease in the United States.

Treatment of pneumococcal infections with penicillin and other drugs used to be more effective. But some strains of the disease have become resistant to these drugs. This makes prevention of the disease, through vaccination, even more important.

2 Pneumococcal polysaccharide vaccine (PPSV23)

Pneumococcal polysaccharide vaccine (PPSV23) protects against 23 types of pneumococcal bacteria. It will not prevent all pneumococcal disease.

PPSV23 is recommended for:

- All adults 65 years of age and older,
- Anyone 2 through 64 years of age with certain long-term health problems,
- Anyone 2 through 64 years of age with a weakened immune system,
- Adults 19 through 64 years of age who smoke cigarettes or have asthma.

Most people need only one dose of PPSV. A second dose is recommended for certain high-risk groups. People 65 and older should get a dose even if they have gotten one or more doses of the vaccine before they turned 65.

Your healthcare provider can give you more information about these recommendations.

Most healthy adults develop protection within 2 to 3 weeks of getting the shot.

3 Some people should not get this vaccine

- Anyone who has had a life-threatening allergic reaction to PPSV should not get another dose.
- Anyone who has a severe allergy to any component of PPSV should not receive it. Tell your provider if you have any severe allergies.
- Anyone who is moderately or severely ill when the shot is scheduled may be asked to wait until they recover before getting the vaccine. Someone with a mild illness can usually be vaccinated.
- Children less than 2 years of age should not receive this vaccine.
- There is no evidence that PPSV is harmful to either a pregnant woman or to her fetus. However, as a precaution, women who need the vaccine should be vaccinated before becoming pregnant, if possible.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

4 Risks of a vaccine reaction

With any medicine, including vaccines, there is a chance of side effects. These are usually mild and go away on their own, but serious reactions are also possible.

About half of people who get PPSV have mild side effects, such as redness or pain where the shot is given, which go away within about two days.

Less than 1 out of 100 people develop a fever, muscle aches, or more severe local reactions.

Problems that could happen after any vaccine:

- People sometimes faint after a medical procedure, including vaccination. Sitting or lying down for about 15 minutes can help prevent fainting, and injuries caused by a fall. Tell your doctor if you feel dizzy, or have vision changes or ringing in the ears.
- Some people get severe pain in the shoulder and have difficulty moving the arm where a shot was given. This happens very rarely.
- Any medication can cause a severe allergic reaction. Such reactions from a vaccine are very rare, estimated at about 1 in a million doses, and would happen within a few minutes to a few hours after the vaccination.

As with any medicine, there is a very remote chance of a vaccine causing a serious injury or death.

The safety of vaccines is always being monitored. For more information, visit: **www.cdc.gov/vaccinesafety/**

5 What if there is a serious reaction?

What should I look for?

Look for anything that concerns you, such as signs of a severe allergic reaction, very high fever, or unusual behavior.

Signs of a **severe allergic reaction** can include hives, swelling of the face and throat, difficulty breathing, a fast heartbeat, dizziness, and weakness. These would usually start a few minutes to a few hours after the vaccination.

What should I do?

If you think it is a severe allergic reaction or other emergency that can't wait, call 9-1-1 or get to the nearest hospital. Otherwise, call your doctor.

Afterward, the reaction should be reported to the Vaccine Adverse Event Reporting System (VAERS). Your doctor might file this report, or you can do it yourself through the VAERS web site at **www.vaers.hhs.gov**, or by calling **1-800-822-7967**.

VAERS does not give medical advice.

6 How can I learn more?

- Ask your doctor. He or she can give you the vaccine package insert or suggest other sources of information.
- Call your local or state health department.
- Contact the Centers for Disease Control and Prevention (CDC):
  - Call **1-800-232-4636 (1-800-CDC-INFO)** or
  - Visit CDC's website at **www.cdc.gov/vaccines**

Vaccine Information Statement
PPSV Vaccine

4/24/2015

Office Use Only

Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger, UNITED STATES, 2018

- Consult relevant ACIP statements for detailed recommendations (www.cdc.gov/vaccines/hcp/acip-recs/index.html).
- When a vaccine is not administered at the recommended age, administer at a subsequent visit.
- Use combination vaccines instead of separate injections when appropriate.
- Report clinically significant adverse events to the Vaccine Adverse Event Reporting System (VAERS) online (www.vaers.hhs.gov) or by telephone (800-822-7967).
- Report suspected cases of reportable vaccine-preventable diseases to your state or local health department.
- For information about precautions and contraindications, see www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.

Approved by the

Advisory Committee on Immunization Practices
(www.cdc.gov/vaccines/acip)

American Academy of Pediatrics
(www.aap.org)

American Academy of Family Physicians
(www.aafp.org)

American College of Obstetricians and Gynecologists
(www.acog.org)

This schedule includes recommendations in effect as of January 1, 2018.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

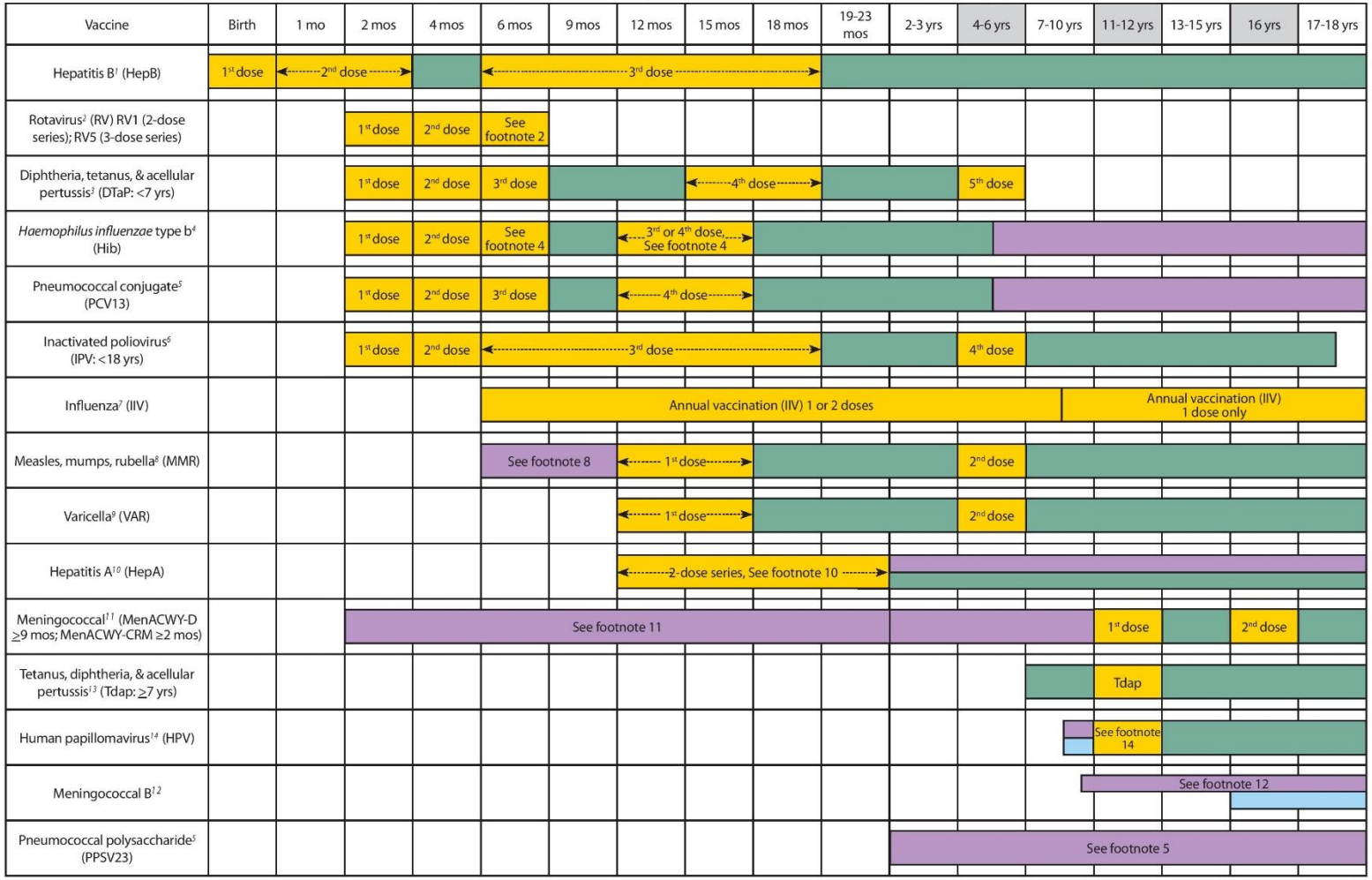
The table below shows vaccine acronyms, and brand names for vaccines routinely recommended for children and adolescents. The use of trade names in this immunization schedule is for identification purposes only and does not imply endorsement by the ACIP or CDC.

Vaccine type	Abbreviation	Brand(s)
Diphtheria, tetanus, and acellular pertussis vaccine	DTaP	Daptacel Infanrix
Diphtheria, tetanus vaccine	DT	No Trade Name
Haemophilus influenzae type B vaccine	Hib (PRP-T) Hib (PRP-OMP)	ActHIB Hiberix PedvaxHIB
Hepatitis A vaccine	HepA	Havrix Vaqta
Hepatitis B vaccine	HepB	Engerix-B Recombivax HB
Human papillomavirus vaccine	HPV	Gardasil 9
Influenza vaccine (inactivated)	IIV	Multiple
Measles, mumps, and rubella vaccine	MMR	M-M-R II
Meningococcal serogroups A, C, W, Y vaccine	MenACWY-D MenACWY-CRM	Menactra Menveo
Meningococcal serogroup B vaccine	MenB-4C MenB-FHbp	Bexsero Trumenba
Pneumococcal 13-valent conjugate vaccine	PCV13	Prevnar 13
Pneumococcal 23-valent polysaccharide vaccine	PPSV23	Pneumovax
Poliovirus vaccine (inactivated)	IPV	IPOL
Rotavirus vaccines	RV1 RV5	Rotarix RotaTeq
Tetanus, diphtheria, and acellular pertussis vaccine	Tdap	Adacel Boostrix
Tetanus and diphtheria vaccine	Td	Tenivac No Trade Name
Varicella vaccine	VAR	Varivax
Combination Vaccines		
DTaP, hepatitis B and inactivated poliovirus vaccine	DTaP-HepB-IPV	Pediarix
DTaP, inactivated poliovirus and *Haemophilus influenzae* type B vaccine	DTaP-IPV/Hib	Pentacel
DTaP and inactivated poliovirus vaccine	DTaP-IPV	Kinrix Quadracel
Measles, mumps, rubella, and varicella vaccines	MMRV	ProQuad

Figure 1. Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018.

(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are shaded in gray.



NOTE: The above recommendations must be read along with the footnotes of this schedule.

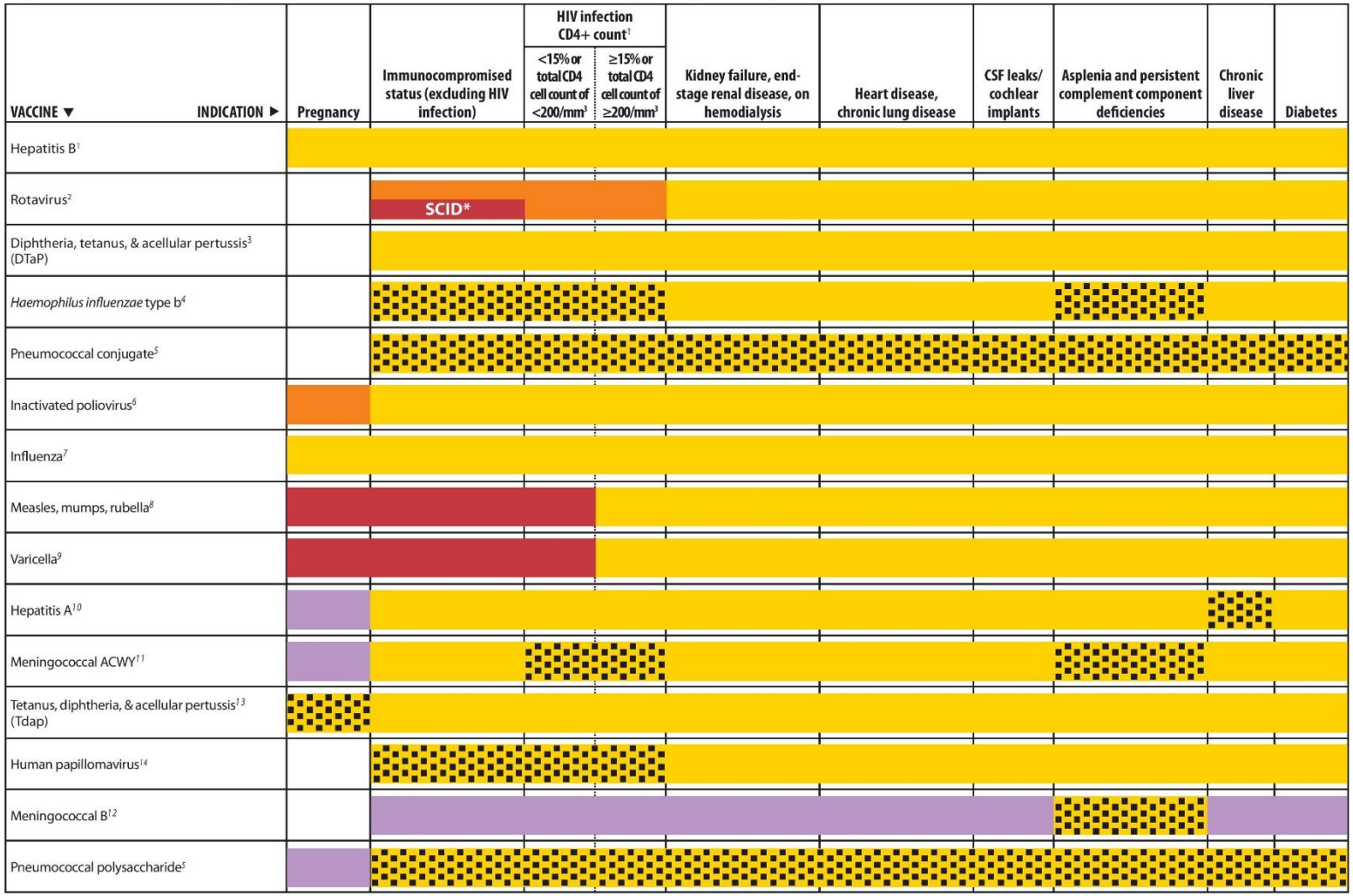
FIGURE 2. Catch-up immunization schedule for persons aged 4 months–18 years who start late or who are more than 1 month behind—United States, 2018.

The figure below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. Always use this table in conjunction with Figure 1 and the footnotes that follow.

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to Dose 2	Dose 2 to Dose 3	Dose 3 to Dose 4	Dose 4 to Dose 5
Children age 4 months through 6 years					
Hepatitis B[1]	Birth	4 weeks	8 weeks ***and*** at least 16 weeks after first dose. Minimum age for the final dose is 24 weeks.		
Rotavirus[2]	6 weeks Maximum age for first dose is 14 weeks, 6 days	4 weeks	4 weeks[2] Maximum age for final dose is 8 months, 0 days.		
Diphtheria, tetanus, and acellular pertussis[3]	6 weeks	4 weeks	4 weeks	6 months	6 months[3]
Haemophilus influenzae type b[4]	6 weeks	4 weeks if first dose was administered before the 1st birthday. 8 weeks (as final dose) if first dose was administered at age 12 through 14 months. No further doses needed if first dose was administered at age 15 months or older.	4 weeks[4] if current age is younger than 12 months **and** first dose was administered at younger than age 7 months, **and** at least 1 previous dose was PRP-T (ActHib, Pentacel, Hiberix) or unknown. 8 weeks ***and*** age 12 through 59 months (as final dose)[4] • if current age is younger than 12 months **and** first dose was administered at age 7 through 11 months; OR • if current age is 12 through 59 months **and** first dose was administered before the 1st birthday, **and** second dose administered at younger than 15 months; OR • if both doses were PRP-OMP (PedvaxHIB; Comvax) **and** were administered before the 1st birthday. No further doses needed if previous dose was administered at age 15 months or older.	8 weeks (as final dose) This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal conjugate[5]	6 weeks	4 weeks if first dose administered before the 1st birthday. 8 weeks (as final dose for healthy children) if first dose was administered at the 1st birthday or after. No further doses needed for healthy children if first dose was administered at age 24 months or older.	4 weeks if current age is younger than 12 months and previous dose given at <7 months old. 8 weeks (as final dose for healthy children) if previous dose given between 7-11 months (wait until at least 12 months old); OR if current age is 12 months or older and at least 1 dose was given before age 12 months. No further doses needed for healthy children if previous dose administered at age 24 months or older.	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age.	
Inactivated poliovirus[6]	6 weeks	4 weeks[6]	4 weeks[6] if current age is < 4 years 6 months (as final dose) if current age is 4 years or older	6 months[6] (minimum age 4 years for final dose).	
Measles, mumps, rubella[8]	12 months	4 weeks			
Varicella[9]	12 months	3 months			
Hepatitis A[10]	12 months	6 months			
Meningococcal[11] (MenACWY-D ≥9 mos; MenACWY-CRM ≥2 mos)	6 weeks	8 weeks[11]	See footnote 11	See footnote 11	
Children and adolescents age 7 through 18 years					
Meningococcal[11] (MenACWY-D ≥9 mos; MenACWY-CRM ≥2 mos)	Not Applicable (N/A)	8 weeks[11]			
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis[13]	7 years[13]	4 weeks	4 weeks if first dose of DTaP/DT was administered before the 1st birthday. 6 months (as final dose) if first dose of DTaP/DT or Tdap/Td was administered at or after the 1st birthday.	6 months if first dose of DTaP/DT was administered before the 1st birthday.	
Human papillomavirus[14]	9 years	Routine dosing intervals are recommended.[14]			
Hepatitis A[10]	N/A	6 months			
Hepatitis B[1]	N/A	4 weeks	8 weeks **and** at least 16 weeks after first dose.		
Inactivated poliovirus[6]	N/A	4 weeks	6 months[6] A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.	A fourth dose of IPV is indicated if all previous doses were administered at <4 years or if the third dose was administered <6 months after the second dose.	
Measles, mumps, rubella[8]	N/A	4 weeks			
Varicella[9]	N/A	3 months if younger than age 13 years. 4 weeks if age 13 years or older.			

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Figure 3. Vaccines that might be indicated for children and adolescents aged 18 years or younger based on medical indications



*Severe Combined Immunodeficiency

†For additional information regarding HIV laboratory parameters and use of live vaccines; see the General Best Practice Guidelines for Immunization "Altered Immunocompetence" at: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html; and Table 4-1 (footnote D) at: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.

NOTE: The above recommendations must be read along with the footnotes of this schedule.

Footnotes — Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger, UNITED STATES, 2018

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.
For vaccine recommendations for persons 19 years of age and older, see the Adult Immunization Schedule.

Additional information

- For information on contraindications and precautions for the use of a vaccine, consult the *General Best Practice Guidelines for Immunization* and relevant ACIP statements, at www.cdc.gov/vaccines/hcp/acip-recs/index.html.
- For calculating intervals between doses, 4 weeks = 28 days. Intervals of ≥4 months are determined by calendar months.
- Within a number range (e.g., 12–18), a dash (–) should be read as "through."
- Vaccine doses administered ≤4 days before the minimum age or interval are considered valid. Doses of any vaccine administered ≥5 days earlier than the minimum interval or minimum age should not be counted as valid and should be repeated as age-appropriate. The repeat dose should be spaced after the invalid dose by the recommended minimum interval. For further details, see Table 3-1, *Recommended and minimum ages and intervals between vaccine doses,* in *General Best Practice Guidelines for Immunization* at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/timing.html.
- Information on travel vaccine requirements and recommendations is available at wwwnc.cdc.gov/travel/.
- For vaccination of persons with immunodeficiencies, see Table 8-1, *Vaccination of persons with primary and secondary immunodeficiencies,* in *General Best Practice Guidelines for Immunization,* at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html; and Immunization in Special Clinical Circumstances. (In: Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *Red Book: 2015 report of the Committee on Infectious Diseases. 30th ed.* Elk Grove Village, IL: American Academy of Pediatrics, 2015:68-107).
- The National Vaccine Injury Compensation Program (VICP) is a no-fault alternative to the traditional legal system for resolving vaccine injury claims. All routine child and adolescent vaccines are covered by VICP except for pneumococcal polysaccharide vaccine (PPSV23). For more information; see www.hrsa.gov/vaccinecompensation/index.html.

1. Hepatitis B (HepB) vaccine. (minimum age: birth)

Birth Dose (Monovalent HepB vaccine only):

- **Mother is HBsAg-Negative:** 1 dose within 24 hours of birth for medically stable infants ≥2,000 grams. Infants <2,000 grams administer 1 dose at chronological age 1 month or hospital discharge.
- **Mother is HBsAg-Positive:**
  - Give **HepB vaccine** and **0.5 mL of HBIG** (at separate anatomic sites) within 12 hours of birth, regardless of birth weight.
  - Test for HBsAg and anti-HBs at age 9–12 months. If HepB series is delayed, test 1–2 months after final dose.
- **Mother's HBsAg status is unknown:**
  - Give **HepB vaccine** within 12 hours of birth, regardless of birth weight.
  - For infants <2,000 grams, give **0.5 mL of HBIG** in addition to HepB vaccine within 12 hours of birth.
  - Determine mother's HBsAg status as soon as possible. If mother is HBsAg-positive, give **0.5 mL of HBIG** to infants ≥2,000 grams as soon as possible, but no later than 7 days of age.

Routine Series:

- A complete series is 3 doses at 0, 1–2, and 6–18 months. (Monovalent HepB vaccine should be used for doses given before age 6 weeks.)
- Infants who did not receive a birth dose should begin the series as soon as feasible (see Figure 2).
- Administration of **4 doses** is permitted when a combination vaccine containing HepB is used after the birth dose.
- **Minimum age** for the final (3rd or 4th) dose: 24 weeks.
- **Minimum Intervals:** Dose 1 to Dose 2: 4 weeks / Dose 2 to Dose 3: 8 weeks / Dose 1 to Dose 3: 16 weeks. (When 4 doses are given, substitute "Dose 4" for "Dose 3" in these calculations.)

Catch-up vaccination:

- Unvaccinated persons should complete a 3-dose series at 0, 1–2, and 6 months.
- Adolescents 11–15 years of age may use an alternative 2-dose schedule, with at least 4 months between doses (adult formulation **Recombivax HB** only).
- For other catch-up guidance, see Figure 2.

2. Rotavirus vaccines. (minimum age: 6 weeks)

Routine vaccination:

Rotarix: 2-dose series at 2 and 4 months.

RotaTeq: 3-dose series at 2, 4, and 6 months.

If any dose in the series is either RotaTeq or unknown, default to 3-dose series.

Catch-up vaccination:

- Do not start the series on or after age 15 weeks, 0 days.
- The maximum age for the final dose is 8 months, 0 days.
- For other catch-up guidance, see Figure 2.

3. Diphtheria, tetanus, and acellular pertussis (DTaP) vaccine. (minimum age: 6 weeks [4 years for Kinrix or Quadracel])

Routine vaccination:

- 5-dose series at 2, 4, 6, and 15–18 months, and 4–6 years.
  - **Prospectively:** A 4th dose may be given as early as age 12 months if at least 6 months have elapsed since the 3rd dose.
  - **Retrospectively:** A 4th dose that was inadvertently given as early as 12 months may be counted if at least 4 months have elapsed since the 3rd dose.

Catch-up vaccination:

- The 5th dose is not necessary if the 4th dose was administered at 4 years or older.
- For other catch-up guidance, see Figure 2.

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

4. *Haemophilus influenzae* type b (Hib) vaccine. (minimum age: 6 weeks)

Routine vaccination:

- **ActHIB, Hiberix, or Pentacel:** 4-dose series at 2, 4, 6, and 12–15 months.
- **PedvaxHIB:** 3-dose series at 2, 4, and 12–15 months.

Catch-up vaccination:

- **1st dose at 7–11 months:** Give 2nd dose at least 4 weeks later and 3rd (final) dose at 12–15 months or 8 weeks after 2nd dose (whichever is later).
- **1st dose at 12–14 months:** Give 2nd (final) dose at least 8 weeks after 1st dose.
- **1st dose before 12 months and 2nd dose before 15 months:** Give 3rd (final) dose 8 weeks after 2nd dose.
- **2 doses of PedvaxHIB before 12 months:** Give 3rd (final) dose at 12–59 months and at least 8 weeks after 2nd dose.
- **Unvaccinated at 15–59 months:** 1 dose.
- For other catch-up guidance, see Figure 2.

Special Situations:

- **Chemotherapy or radiation treatment**
  12–59 months
  - o Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart
  - o 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Doses given within 14 days of starting therapy or during therapy should be repeated at least 3 months after therapy completion.
- **Hematopoietic stem cell transplant (HSCT)**
- 3-dose series with doses 4 weeks apart starting 6 to 12 months after successful transplant (regardless of Hib vaccination history).
- **Anatomic or functional asplenia (including sickle cell disease)**
  12–59 months
  - o Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart.
  - o 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Unimmunized persons 5 years or older*
  - o Give 1 dose
- **Elective splenectomy**
  Unimmunized* persons 15 months or older
  - o Give 1 dose (preferably at least 14 days before procedure).
- **HIV infection**
  12–59 months
  - o Unvaccinated or only 1 dose before 12 months: Give 2 doses 8 weeks apart.
  - o 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Unimmunized persons 5–18 years*
  - o Give 1 dose
- **Immunoglobulin deficiency, early component complement deficiency**
  12–59 months
  - o Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart.
  - o 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

**Unimmunized* = Less than routine series (through 14 months) OR no doses (14 months or older)*

5. Pneumococcal vaccines. (minimum age: 6 weeks [PCV13], 2 years [PPSV23])

Routine vaccination with PCV13:

- 4-dose series at 2, 4, 6, and 12–15 months.

Catch-up vaccination with PCV13:

- 1 dose for healthy children aged 24–59 months with any incomplete* PCV13 schedule
- For other catch-up guidance, see Figure 2.

Special situations: High-risk conditions:
Administer PCV13 doses before PPSV23 if possible.

Chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma treated with high-dose, oral, corticosteroids); diabetes mellitus:

Age 2–5 years:

- Any incomplete* schedules with:
  - o 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - o <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Age 6-18 years:

- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Cerebrospinal fluid leak; cochlear implant:

Age 2–5 years:

- Any incomplete* schedules with:
  - o 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - o <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Age 6–18 years:

- No history of either PCV13 or PPSV23: 1 dose of PCV13, 1 dose of PPSV23 at least 8 weeks later.
- Any PCV13 but no PPSV23: 1 dose of PPSV23 at least 8 weeks after the most recent dose of PCV13
- PPSV23 but no PCV13: 1 dose of PCV13 at least 8 weeks after the most recent dose of PPSV23.

Sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiency; HIV infection; chronic renal failure; nephrotic syndrome; malignant neoplasms, leukemias, lymphomas, Hodgkin disease, and other diseases associated with treatment with immunosuppressive drugs or radiation therapy; solid organ transplantation; multiple myeloma:

Age 2–5 years:

- Any incomplete* schedules with:
  - o 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - o <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose) and a 2nd dose of PPSV23 5 years later.

Age 6–18 years:

- No history of either PCV13 or PPSV23: 1 dose of PCV13, 2 doses of PPSV23 (1st dose of PPSV23 administered 8 weeks after PCV13 and 2nd dose of PPSV23 administered at least 5 years after the 1st dose of PPSV23).
- Any PCV13 but no PPSV23: 2 doses of PPSV23 (1st dose of PPSV23 to be given 8 weeks after the most recent dose of PCV13 and 2nd dose of PPSV23 administered at least 5 years after the 1st dose of PPSV23).

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

- PPSV23 but no PCV13: 1 dose of PCV13 at least 8 weeks after the most recent PPSV23 dose and a 2nd dose of PPSV23 to be given 5 years after the 1st dose of PPSV23 and at least 8 weeks after a dose of PCV13.

Chronic liver disease, alcoholism:

Age 6–18 years:

- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

*Incomplete schedules are any schedules where PCV13 doses have not been completed according to ACIP recommended catch-up schedules. The total number and timing of doses for complete PCV13 series are dictated by the age at first vaccination. See Tables 8 and 9 in the ACIP pneumococcal vaccine recommendations (www.cdc.gov/mmwr/pdf/rr/rr5911.pdf) for complete schedule details.

6. Inactivated poliovirus vaccine (IPV). (minimum age: 6 weeks)

Routine vaccination:

- 4-dose series at ages 2, 4, 6–18 months, and 4–6 years. Administer the final dose on or after the 4th birthday and at least 6 months after the previous dose.

Catch-up vaccination:

- In the first 6 months of life, use minimum ages and intervals only for travel to a polio-endemic region or during an outbreak.
- If 4 or more doses were given before the 4th birthday, give 1 more dose at age 4–6 years and at least 6 months after the previous dose.
- A 4th dose is not necessary if the 3rd dose was given on or after the 4th birthday and at least 6 months after the previous dose.
- IPV is not routinely recommended for U.S. residents 18 years and older.

Series Containing Oral Polio Vaccine (OPV), *either mixed OPV-IPV or OPV-only series*:

- Total number of doses needed to complete the series is the same as that recommended for the U.S. IPV schedule. See www.cdc.gov/mmwr/volumes/66/wr/mm6601a6.htm?s_cid=mm6601a6_w.
- Only trivalent OPV (tOPV) counts toward the U.S. vaccination requirements. For guidance to assess doses documented as "OPV" see www.cdc.gov/mmwr/volumes/66/wr/mm6606a7.htm?s_cid=mm6606a7_w.
- For other catch-up guidance, see Figure 2.

7. Influenza vaccines. (minimum age: 6 months)

Routine vaccination:

- Administer an age-appropriate formulation and dose of influenza vaccine annually.
  - **Children 6 months–8 years** who did not receive at least 2 doses of influenza vaccine before July 1, 2017 should receive 2 doses separated by at least 4 weeks.
  - **Persons 9 years and older** 1 dose
- Live attenuated influenza vaccine (LAIV) not recommended for the 2017–18 season.
- For additional guidance, see the 2017–18 ACIP influenza vaccine recommendations (*MMWR* August 25, 2017;66(2):1-20: www.cdc.gov/mmwr/volumes/66/rr/pdfs/rr6602.pdf).

(For the 2018–19 season, see the 2018–19 ACIP influenza vaccine recommendations.)

8. Measles, mumps, and rubella (MMR) vaccine. (minimum age: 12 months for routine vaccination)

Routine vaccination:

- 2-dose series at 12–15 months and 4–6 years.
- The 2nd dose may be given as early as 4 weeks after the 1st dose.

Catch-up vaccination:

- Unvaccinated children and adolescents: 2 doses at least 4 weeks apart.

International travel:

- **Infants 6–11 months:** 1 dose before departure. Revaccinate with 2 doses at 12–15 months (12 months for children in high-risk areas) and 2nd dose as early as 4 weeks later.
- **Unvaccinated children 12 months and older:** 2 doses at least 4 weeks apart before departure.

Mumps outbreak:

- Persons ≥12 months who previously received ≤2 doses of mumps-containing vaccine and are identified by public health authorities to be at increased risk during a mumps outbreak should receive a dose of mumps-virus containing vaccine.

9. Varicella (VAR) vaccine. (minimum age: 12 months)

Routine vaccination:

- 2-dose series: 12–15 months and 4–6 years.
- The 2nd dose may be given as early as 3 months after the 1st dose (a dose given after a 4-week interval may be counted).

Catch-up vaccination:

- Ensure persons 7–18 years without evidence of immunity (see *MMWR* 2007;56[No. RR-4], at www.cdc.gov/mmwr/pdf/rr/rr5604.pdf) have 2 doses of varicella vaccine:
  - **Ages 7–12:** routine interval 3 months (minimum interval: 4 weeks).
  - **Ages 13 and older:** minimum interval 4 weeks.

10. Hepatitis A (HepA) vaccine. (minimum age: 12 months)

Routine vaccination:

- 2 doses, separated by 6-18 months, between the 1st and 2nd birthdays. (A series begun before the 2nd birthday should be completed even if the child turns 2 before the second dose is given.)

Catch-up vaccination:

- Anyone 2 years of age or older may receive HepA vaccine if desired. Minimum interval between doses is 6 months.

Special populations:

Previously unvaccinated persons who should be vaccinated:

- Persons traveling to or working in countries with high or intermediate endemicity
- Men who have sex with men
- Users of injection and non-injection drugs
- Persons who work with hepatitis A virus in a research laboratory or with non-human primates
- Persons with clotting-factor disorders
- Persons with chronic liver disease
- Persons who anticipate close, personal contact (e.g., household or regular babysitting) with an international adoptee during the first 60 days after arrival in the United States from a country with high or intermediate endemicity (administer the 1st dose as soon as the adoption is planned—ideally at least 2 weeks before the adoptee's arrival).

11. Serogroup A, C, W, Y meningococcal vaccines. (Minimum age: 2 months [Menveo], 9 months [Menactra].

Routine:

- 2-dose series: 11-12 years and 16 years.

Catch-Up:

- Age 13-15 years: 1 dose now and booster at age 16-18 years. Minimum interval 8 weeks.
- Age 16-18 years: 1 dose.

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

Special populations and situations:
Anatomic or functional asplenia, sickle cell disease, HIV infection, persistent complement component deficiency (including eculizumab use):

- **Menveo**
  - 1st dose at 8 weeks: 4-dose series at 2, 4, 6, and 12 months.
  - 1st dose at 7–23 months: 2 doses (2nd dose at least 12 weeks after the 1st dose and after the 1st birthday).
  - 1st dose at 24 months or older: 2 doses at least 8 weeks apart.
- **Menactra**
  - Persistent complement component deficiency:
    - 9–23 months: 2 doses at least 12 weeks apart
    - 24 months or older: 2 doses at least 8 weeks apart
  - Anatomic or functional asplenia, sickle cell disease, or HIV infection:
    - 24 months or older: 2 doses at least 8 weeks apart.
    - **Menactra** must be administered at least 4 weeks after completion of PCV13 series.

Children who travel to or live in countries where meningococcal disease is hyperendemic or epidemic, including countries in the African meningitis belt or during the Hajj, or exposure to an outbreak attributable to a vaccine serogroup:

- Children <24 months of age:
  - **Menveo (2-23 months):**
    - 1st dose at 8 weeks: 4-dose series at 2, 4, 6, and 12 months.
    - 1st dose at 7-23 months: 2 doses (2nd dose at least 12 weeks after the 1st dose and after the 1st birthday).
  - **Menactra (9-23 months):**
    - 2 doses (2nd dose at least 12 weeks after the 1st dose. 2nd dose may be administered as early as 8 weeks after the 1st dose in travelers).
- Children 2 years or older: 1 dose of **Menveo** or **Menactra**.

Note: Menactra should be given either before or at the same time as DTaP. For MenACWY booster dose recommendations for groups listed under "Special populations and situations" above, and additional meningococcal vaccination information, see meningococcal *MMWR* publications at: www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html.

12. Serogroup B meningococcal vaccines (minimum age: 10 years [Bexsero, Trumenba].

Clinical discretion: Adolescents not at increased risk for meningococcal B infection who want MenB vaccine.

MenB vaccines may be given at clinical discretion to adolescents 16–23 years (preferred age 16–18 years) who are not at increased risk.

- **Bexsero**: 2 doses at least 1 month apart.
- **Trumenba**: 2 doses at least 6 months apart. If the 2nd dose is given earlier than 6 months, give a 3rd dose at least 4 months after the 2nd.

Special populations and situations:
Anatomic or functional asplenia, sickle cell disease, persistent complement component deficiency (including eculizumab use), serogroup B meningococcal disease outbreak

- **Bexsero**: 2-dose series at least 1 month apart.
- **Trumenba**: 3-dose series at 0, 1-2, and 6 months.

Note: **Bexsero** and **Trumenba** are not interchangeable.
For additional meningococcal vaccination information, see meningococcal *MMWR* publications at: www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html.

13. Tetanus, diphtheria, and acellular pertussis (Tdap) vaccine. (minimum age: 11 years for routine vaccinations, 7 years for catch-up vaccination)

Routine vaccination:

- **Adolescents 11–12 years of age:** 1 dose.
- **Pregnant adolescents:** 1 dose during each pregnancy (preferably during the early part of gestational weeks 27–36).
- Tdap may be administered regardless of the interval since the last tetanus- and diphtheria-toxoid-containing vaccine.

Catch-up vaccination:

- **Adolescents 13–18 who have not received Tdap**: 1 dose, followed by a Td booster every 10 years.
- **Persons aged 7–18 years not fully immunized with DTaP**: 1 dose of Tdap as part of the catch-up series (preferably the first dose). If additional doses are needed, use Td.
- **Children 7–10 years** who receive Tdap inadvertently or as part of the catch-up series may receive the routine Tdap dose at 11–12 years.
- **DTaP inadvertently given after the 7th birthday**:
  - **Child 7–10**: DTaP may count as part of catch-up series. Routine Tdap dose at 11-12 may be given.
  - **Adolescent 11–18**: Count dose of DTaP as the adolescent Tdap booster.
- For other catch-up guidance, see Figure 2.

14. Human papillomavirus (HPV) vaccine (minimum age: 9 years)

Routine and catch-up vaccination:

- Routine vaccination for all adolescents at 11–12 years (can start at age 9) and through age 18 if not previously adequately vaccinated. Number of doses dependent on age at initial vaccination:
  - **Age 9–14 years at initiation:** 2-dose series at 0 and 6–12 months. Minimum interval: 5 months (repeat a dose given too soon at least 12 weeks after the invalid dose and at least 5 months after the 1st dose).
  - **Age 15 years or older at initiation:** 3-dose series at 0, 1–2 months, and 6 months. Minimum intervals: 4 weeks between 1st and 2nd dose; 12 weeks between 2nd and 3rd dose; 5 months between 1st and 3rd dose (repeat dose(s) given too soon at or after the minimum interval since the most recent dose).
- Persons who have completed a valid series with any HPV vaccine do not need any additional doses.

Special situations:

- **History of sexual abuse or assault**: Begin series at age 9 years.
- **Immunocompromised* (including HIV)** aged 9–26 years: 3-dose series at 0, 1–2 months, and 6 months.
- **Pregnancy:** Vaccination not recommended, but there is no evidence the vaccine is harmful. No intervention is needed for women who inadvertently received a dose of HPV vaccine while pregnant. Delay remaining doses until after pregnancy. Pregnancy testing not needed before vaccination.

*See MMWR, December 16, 2016;65(49):1405–1408, at www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6549a5.pdf.

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Appendix F – CDC – Catch-Up Guidance for Healthy Children 4 Months through 4 Years of Age – Pneumococcal Conjugate Vaccine: PCV

Catch-Up Guidance for Healthy[1] Children 4 Months through 4 Years of Age

Pneumococcal Conjugate Vaccine: PCV

The table below provides guidance for children whose vaccinations have been delayed. Start with the child's age and information on previous doses (previous doses must be documented and must meet minimum age requirements and minimum intervals between doses). Use this table in conjunction with figure 2 of the Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger, found at www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html.

IF current age is	AND # of previous doses is	AND		THEN	Next dose due
4-6 months	0 or unknown	→	→	Give Dose 1 today	Give Dose 2 at least 4 weeks after Dose 1
	1	→	It has been at least 4 weeks since Dose 1	Give Dose 2 today	Give Dose 3 at least 4 weeks after Dose 2
		→	It has **not** been at least 4 weeks since Dose 1	No dose today	Give Dose 2 at least 4 weeks after Dose 1
	2	→	It has been at least 4 weeks since Dose 2	Give Dose 3 today	Give Dose 4 (**Final Dose**) at 12 months of age or older
		→	It has **not** been at least 4 weeks since Dose 2	No dose today	Give Dose 3 at least 4 weeks after Dose 2
7-11 months	0	→	→	Give Dose 1 Today	Give Dose 2 at least 4 weeks after Dose 1
	1	Dose 1 was given **before** 7 months of age	It has been at least 4 weeks since Dose 1	Give Dose 2 today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2 **and** at 12 months of age or older
			It has **not** been 4 weeks since Dose 1	No dose today	Give Dose 2 at least 4 weeks after Dose 1
		Dose 1 was given at 7 months or older	It has been at least 4 weeks since Dose 1	Give Dose 2 today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2 **and** at 12 months of age or older
			It has **not** been 4 weeks since Dose 1	No dose today	Give Dose 2 at least 4 weeks after Dose 1
	2	Dose 2 was given **before** 7 months of age	It has been at least 4 weeks since Dose 2	Give Dose 3 today	Give Dose 4 (**Final Dose**) at least 8 weeks after Dose 3 **and** at 12 months of age or older
			It has **not** been 4 weeks since Dose 2	No dose today	Give Dose 3 at least 4 weeks after Dose 2
		Dose 2 was given at 7 months or older	→	No dose today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2 **and** at 12 months of age or older

[1] Refer to footnote 5 of the 2018 Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger for immunization guidance for children at increased risk for pneumococcal disease.

Reference: Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018. www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf

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Catch-Up Guidance for Healthy[1] Children 4 Months through 4 Years of Age

Pneumococcal Conjugate Vaccine: PCV

IF current age is	AND # of previous doses is	AND	AND	THEN	Next dose due
12-23 months	0 or unknown	→	→	Give Dose 1 today	Give Dose 2 (**Final Dose**) at least 8 weeks after Dose 1
	1	Dose 1 was given **before** 12 months of age	It has been at least 4 weeks since Dose 1	Give Dose 2 today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2
			It has **not** been 4 weeks since Dose 1	No dose today	Give Dose 2 at least 4 weeks after Dose 1
		Dose 1 was given at 12 months of age or older	It has been at least 8 weeks since Dose 1	Give Dose 2 (**Final Dose**) today	**No additional doses needed**
			It has **not** been 8 weeks since Dose 1	No dose today	Give Dose 2 (**Final Dose**) at least 8 weeks after Dose 1
	2	Both doses were given **before** 12 months of age	It has been at least 8 weeks since Dose 2	Give Dose 3 (**Final dose**) today	**No additional doses needed**
			It has **not** been 8 weeks since Dose 2	No dose today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2
		At least one dose was given at 12 months or older	It has been at least 8 weeks since Dose 2	Give Dose 3 (**Final Dose**) today	**No additional doses needed**
			It has **not** been 8 weeks since Dose 2	No dose today	Give Dose 3 (**Final Dose**) at least 8 weeks after Dose 2
		Both doses were given at 12 months or older[2]	→	No dose today	**No additional doses needed**
	3	All doses were given **before** 12 months of age	It has been at least 8 weeks since Dose 3	Give Dose 4 (**Final Dose**) today	**No additional doses needed**
			It has **not** been 8 weeks since Dose 3	No dose today	Give Dose 4 (**Final Dose**) at least 8 weeks after Dose 3
		1 or more doses were given at 12 months of age or older	→	No dose today	**No additional doses needed**

[1] Refer to the footnote 5 of the 2018 2018 Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger for immunization guidance for children at increased risk for pneumococcal disease.

[2] Separated by at least 8 weeks.

Reference: 2018 Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018. www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf

Catch-Up Guidance for Healthy[1] Children 4 Months through 4 Years of Age

Pneumococcal Conjugate Vaccine: PCV

IF current age is	AND # of previous doses is	AND	AND	THEN	Next dose due
24-59 months	0	→	→	Give Dose 1 today	**No additional doses needed**
	1	Dose 1 was given **before** 24 months of age	It has been at least 8 weeks since the first dose	Give Dose 2 (**Final Dose**) today	**No additional doses needed**
			It has **not** been 8 weeks since the first dose	No dose today	Give Dose 2 (**Final Dose**) at least 8 weeks after Dose 1
		Dose 1 was given at 24 months or older	→	No dose today	**No additional doses needed**
	2	Dose 1 was given **before** 12 months of age	→	Give Dose 3 (**Final Dose**) today	**No additional doses needed**
		Dose 1 was given **after** 12 months of age	→	No dose today	**No additional doses needed**
	3	All 3 doses were given **before** 12 months of age	→	Give Dose 4 (**Final Dose**) today	**No additional doses needed**
		1 dose was at 12 months or older	→	No dose today	**No additional doses needed**

[1] Refer to the footnote 5 of the 2018 Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger for immunization guidance for children at increased risk for pneumococcal disease.

Reference: 2018 Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018. www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf

Appendix G – CDC – Recommended Immunization Schedule for Adults Aged 19 Years or Older, United States, 2018

Recommended Immunization Schedule for Adults Aged 19 Years or Older, United States, 2018

In February 2018, the *Recommended Immunization Schedule for Adults Aged 19 Years or Older, United States, 2018* became effective, as recommended by the Advisory Committee on Immunization Practices (ACIP) and approved by the Centers for Disease Control and Prevention (CDC). The adult immunization schedule was also approved by the American College of Physicians, the American Academy of Family Physicians, the American College of Obstetricians and Gynecologists, and the American College of Nurse-Midwives.

CDC announced the availability of the 2018 adult immunization schedule in the *Morbidity and Mortality Weekly Report (MMWR)*.[1] The schedule is published in its entirety in the *Annals of Internal Medicine*.[2]

The adult immunization schedule consists of figures that summarize routinely recommended vaccines for adults by age groups and medical conditions, footnotes for the figures, and a table of vaccine contraindications and precautions. Note the following when reviewing the adult immunization schedule:

- The figures in the adult immunization schedule should be reviewed with the accompanying footnotes.
- The figures and footnotes display indications for which vaccines, if not previously administered, should be administered unless noted otherwise.
- The table of contraindications and precautions identifies populations and situations for which vaccines should not be used or should be used with caution.
- When indicated, administer recommended vaccines to adults whose vaccination history is incomplete or unknown.
- Increased interval between doses of a multidose vaccine series does not diminish vaccine effectiveness; it is not necessary to restart the vaccine series or add doses to the series because of an extended interval between doses.
- Combination vaccines may be used when any component of the combination is indicated and when the other components of the combination are not contraindicated.
- The use of trade names in the adult immunization schedule is for identification purposes only and does not imply endorsement by the ACIP or CDC.

Special populations that need additional considerations include:

- Pregnant women. Pregnant women should receive the tetanus, diphtheria, and acellular pertussis vaccine (Tdap) during pregnancy and the influenza vaccine during or before pregnancy. Live vaccines (e.g., measles, mumps, and rubella vaccine [MMR]) are contraindicated.
- Asplenia. Adults with asplenia have specific vaccination recommendations because of their increased risk for infection by encapsulated bacteria. Anatomical or functional asplenia includes congenital or acquired asplenia, splenic dysfunction, sickle cell disease and other hemoglobinopathies, and splenectomy.
- Immunocompromising conditions. Adults with immunosuppression should generally avoid live vaccines. Inactivated vaccines (e.g., pneumococcal vaccines) are generally acceptable. High-level immunosuppression includes HIV infection with a CD4 cell count <200 cells/μL, receipt of daily corticosteroid therapy with ≥20 mg of prednisone or equivalent for ≥14 days, primary immunodeficiency disorder (e.g., severe combined immunodeficiency or complement component deficiency), and receipt of cancer chemotherapy. Other immunocompromising conditions and immunosuppressive medications to consider when vaccinating adults can be found in *IDSA Clinical Practice Guideline for Vaccination of the Immunocompromised Host*.[3] Additional information on vaccinating immunocompromised adults is in *General Best Practice Guidelines for Immunization*.[4]

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Additional resources for health care providers include:

- Details on vaccines recommended for adults and complete ACIP statements at www.cdc.gov/vaccines/hcp/acip-recs/index.html
- Vaccine Information Statements that explain benefits and risks of vaccines at www.cdc.gov/vaccines/hcp/vis/index.html
- Information and resources on vaccinating pregnant women at www.cdc.gov/vaccines/adults/rec-vac/pregnant.html
- Information on travel vaccine requirements and recommendations at www.cdc.gov/travel/destinations/list
- CDC Vaccine Schedules App for immunization service providers to download at www.cdc.gov/vaccines/schedules/hcp/schedule-app.html
- Adult Vaccination Quiz for self-assessment of vaccination needs based on age, health conditions, and other indications at www2.cdc.gov/nip/adultimmsched/default.asp
- *Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger* at www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html

Report suspected cases of reportable vaccine-preventable diseases to the local or state health department, and report all clinically significant postvaccination events to the Vaccine Adverse Event Reporting System at www.vaers.hhs.gov or by telephone, 800-822-7967. All vaccines included in the adult immunization schedule except 23-valent pneumococcal polysaccharide and zoster vaccines are covered by the Vaccine Injury Compensation Program. Information on how to file a vaccine injury claim is available at www.hrsa.gov/vaccinecompensation or by telephone, 800-338-2382. Submit questions and comments to CDC through www.cdc.gov/cdc-info or by telephone, 800-CDC-INFO (800-232-4636), in English and Spanish, 8:00am–8:00pm ET, Monday–Friday, excluding holidays.

The following abbreviations are used for vaccines in the adult immunization schedule (in the order of their appearance):

IIV	inactivated influenza vaccine
RIV	recombinant influenza vaccine
Tdap	tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine
Td	tetanus and diphtheria toxoids
MMR	measles, mumps, and rubella vaccine
VAR	varicella vaccine
RZV	recombinant zoster vaccine
ZVL	zoster vaccine live
HPV vaccine	human papillomavirus vaccine
PCV13	13-valent pneumococcal conjugate vaccine
PPSV23	23-valent pneumococcal polysaccharide vaccine
HepA	hepatitis A vaccine
HepA-HepB	hepatitis A vaccine and hepatitis B vaccine
HepB	hepatitis B vaccine
MenACWY	serogroups A, C, W, and Y meningococcal vaccine
MenB	serogroup B meningococcal vaccine
Hib	*Haemophilus influenzae* type b vaccine

1. MMWR Morb Mortal Wkly Rep. 2018;66(5). Available at www.cdc.gov/mmwr/volumes/67/wr/mm6705e3.htm.
2. Ann Intern Med. 2018;168:210–220. Available at annals.org/aim/article/doi/10.7326/M17-3439.
3. Clin Infect Dis. 2014;58:e44-100. Available at www.idsociety.org/Templates/Content.aspx?id=32212256011.
4. ACIP. Available at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html.

Figure 1. Recommended immunization schedule for adults aged 19 years or older by age group, United States, 2018

This figure should be reviewed with the accompanying footnotes. This figure and the footnotes describe indications for which vaccines, if not previously administered, should be administered unless noted otherwise.

Vaccine	19–21 years	22–26 years	27–49 years	50–64 years	≥65 years
Influenza[1]	1 dose annually				
Tdap[2] or Td[2]	1 dose Tdap, then Td booster every 10 yrs				
MMR[3]	1 or 2 doses depending on indication (if born in 1957 or later)				
VAR[4]	2 doses				
RZV[5] (preferred)				2 doses RZV (preferred)	
or				or	
ZVL[5]				1 dose ZVL	
HPV–Female[6]	2 or 3 doses depending on age at series initiation				
HPV–Male[6]	2 or 3 doses depending on age at series initiation				
PCV13[7]	1 dose				
PPSV23[7]	1 or 2 doses depending on indication				1 dose
HepA[8]	2 or 3 doses depending on vaccine				
HepB[9]	3 doses				
MenACWY[10]	1 or 2 doses depending on indication, then booster every 5 yrs if risk remains				
MenB[10]	2 or 3 doses depending on vaccine				
Hib[11]	1 or 3 doses depending on indication				

Recommended for adults who meet the age requirement, lack documentation of vaccination, or lack evidence of past infection

Recommended for adults with other indications

No recommendation

Figure 2. Recommended immunization schedule for adults aged 19 years or older by medical condition and other indications, United States, 2018

This figure should be reviewed with the accompanying footnotes. This figure and the footnotes describe indications for which vaccines, if not previously administered, should be administered unless noted otherwise.

Vaccine	Pregnancy[1-6]	Immuno-compromised (excluding HIV infection)[3-7,11]	HIV infection CD4+ count (cells/µL)[3-7,9-10]		Asplenia, complement deficiencies[7,10,11]	End-stage renal disease, on hemodialysis[7,9]	Heart or lung disease, alcoholism[7]	Chronic liver disease[7-9]	Diabetes[7,9]	Health care personnel[3,4,9]	Men who have sex with men[6,8,9]
			<200	≥200							
Influenza[1]	1 dose annually										
Tdap[2] or Td[2]	1 dose Tdap each pregnancy	1 dose Tdap, then Td booster every 10 yrs									
MMR[3]	contraindicated			1 or 2 doses depending on indication							
VAR[4]	contraindicated			2 doses							
RZV[5] (preferred)					2 doses RZV at age ≥50 yrs (preferred)						
or					or						
ZVL[5]	contraindicated				1 dose ZVL at age ≥60 yrs						
HPV–Female[6]		3 doses through age 26 yrs			2 or 3 doses through age 26 yrs						
HPV–Male[6]		3 doses through age 26 yrs			2 or 3 doses through age 21 yrs						2 or 3 doses through age 26 yrs
PCV13[7]		1 dose									
PPSV23[7]		1, 2, or 3 doses depending on indication									
HepA[8]	2 or 3 doses depending on vaccine										
HepB[9]	3 doses										
MenACWY[10]	1 or 2 doses depending on indication , then booster every 5 yrs if risk remains										
MenB[10]	2 or 3 doses depending on vaccine										
Hib[11]	3 doses HSCT recipients only		1 dose								

Recommended for adults who meet the age requirement, lack documentation of vaccination, or lack evidence of past infection

Recommended for adults with other indications

Contraindicated

No recommendation

Footnotes. Recommended immunization schedule for adults aged 19 years or older, United States, 2018

1. Influenza vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/flu.html

General information

- Administer 1 dose of age-appropriate inactivated influenza vaccine (IIV) or recombinant influenza vaccine (RIV) annually
- Live attenuated influenza vaccine (LAIV) is not recommended for the 2017–2018 influenza season
- A list of currently available influenza vaccines is available at www.cdc.gov/flu/protect/vaccine/vaccines.htm

Special populations

- Administer age-appropriate IIV or RIV to:
  - **Pregnant women**
  - Adults with **hives-only egg allergy**
  - Adults with **egg allergy other than hives** (e.g., angioedema or respiratory distress): Administer IIV or RIV in a medical setting under supervision of a health care provider who can recognize and manage severe allergic conditions

2. Tetanus, diphtheria, and pertussis vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/tdap-td.html

General information

- Administer to adults who previously did not receive a dose of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine (Tdap) as an adult or child (routinely recommended at age 11–12 years) 1 dose of Tdap, followed by a dose of tetanus and diphtheria toxoids (Td) booster every 10 years
- Information on the use of Tdap or Td as tetanus prophylaxis in wound management is available at www.cdc.gov/mmwr/preview/mmwrhtml/rr5517a1.htm

Special populations

- **Pregnant women**: Administer 1 dose of Tdap during each pregnancy, preferably in the early part of gestational weeks 27–36

3. Measles, mumps, and rubella vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mmr.html

General information

- Administer 1 dose of measles, mumps, and rubella vaccine (MMR) to adults with no evidence of immunity to measles, mumps, or rubella
- Evidence of immunity is:
  - Born before 1957 (except for health care personnel, see below)
  - Documentation of receipt of MMR
  - Laboratory evidence of immunity or disease
- Documentation of a health care provider-diagnosed disease without laboratory confirmation is not considered evidence of immunity

Special populations

- **Pregnant women and nonpregnant women of childbearing age** with no evidence of immunity to rubella: Administer 1 dose of MMR (if pregnant, administer MMR after pregnancy and before discharge from health care facility)
- **HIV infection and CD4 cell count ≥200 cells/μL for at least 6 months** and no evidence of immunity to measles, mumps, or rubella: Administer 2 doses of MMR at least 28 days apart
- **Students in postsecondary educational institutions, international travelers**, and **household contacts of immunocompromised persons**: Administer 2 doses of MMR at least 28 days apart (or 1 dose of MMR if previously administered 1 dose of MMR)
- **Health care personnel born in 1957 or later** with no evidence of immunity: Administer 2 doses of MMR at least 28 days apart for measles or mumps, or 1 dose of MMR for rubella (if born before 1957, consider MMR vaccination)
- Adults who **previously received ≤2 doses of mumps-containing vaccine and are identified by public health authority to be at increased risk for mumps in an outbreak**: Administer 1 dose of MMR
- MMR is contraindicated for pregnant women and adults with severe immunodeficiency

4. Varicella vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/varicella.html

General information

- Administer to adults without evidence of immunity to varicella 2 doses of varicella vaccine (VAR) 4–8 weeks apart if previously received no varicella-containing vaccine (if previously received 1 dose of varicella-containing vaccine, administer 1 dose of VAR at least 4 weeks after the first dose)
- Evidence of immunity to varicella is:
  - U.S.-born before 1980 (except for pregnant women and health care personnel, see below)
  - Documentation of receipt of 2 doses of varicella or varicella-containing vaccine at least 4 weeks apart
  - Diagnosis or verification of history of varicella or herpes zoster by a health care provider
  - Laboratory evidence of immunity or disease

Special populations

- Administer 2 doses of VAR 4–8 weeks apart if previously received no varicella-containing vaccine (if previously received 1 dose of varicella-containing vaccine, administer 1 dose of VAR at least 4 weeks after the first dose) to:
  - **Pregnant women without evidence of immunity**: Administer the first of the 2 doses or the second dose after pregnancy and before discharge from health care facility
  - **Health care personnel without evidence of immunity**
- Adults with **HIV infection and CD4 cell count ≥200 cells/μL**: May administer, based on individual clinical decision, 2 doses of VAR 3 months apart
- VAR is contraindicated for pregnant women and adults with severe immunodeficiency

5. Zoster vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/shingles.html

General information

- Administer 2 doses of recombinant zoster vaccine (RZV) 2–6 months apart to adults aged 50 years or older regardless of past episode of herpes zoster or receipt of zoster vaccine live (ZVL)
- Administer 2 doses of RZV 2–6 months apart to adults who previously received ZVL at least 2 months after ZVL
- For adults aged 60 years or older, administer either RZV or ZVL (RZV is preferred)

Special populations

- ZVL is contraindicated for pregnant women and adults with severe immunodeficiency

6. Human papillomavirus vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hpv.html

General information

- Administer human papillomavirus (HPV) vaccine to **females through age 26 years** and **males through age 21 years** (males aged 22 through 26 years may be vaccinated based on individual clinical decision)
- The number of doses of HPV vaccine to be administered depends on age at initial HPV vaccination
  - **No previous dose of HPV vaccine**: Administer 3-dose series at 0, 1–2, and 6 months (minimum intervals: 4 weeks between doses 1 and 2, 12 weeks between doses 2 and 3, and 5 months between doses 1 and 3; repeat doses if given too soon)
  - **Aged 9–14 years at HPV vaccine series initiation and received 1 dose or 2 doses less than 5 months apart**: Administer 1 dose
  - **Aged 9–14 years at HPV vaccine series initiation and received 2 doses at least 5 months apart**: No additional dose is needed

Special populations

- Adults with **immunocompromising conditions (including HIV infection)** through age 26 years: Administer 3-dose series at 0, 1–2, and 6 months
- **Men who have sex with men** through age 26 years: Administer 2- or 3-dose series depending on age at initial vaccination (see above); if no history of HPV vaccine, administer 3-dose series at 0, 1–2, and 6 months
- **Pregnant women** through age 26 years: HPV vaccination is not recommended during pregnancy, but there is no evidence that the vaccine is harmful and no intervention needed for women who inadvertently receive HPV vaccine while pregnant; delay remaining doses until after pregnancy; pregnancy testing is not needed before vaccination

7. Pneumococcal vaccination
www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/pneumo.html

General information

- Administer to immunocompetent adults aged 65 years or older 1 dose of 13-valent pneumococcal conjugate vaccine (PCV13), if not previously administered, followed by 1 dose of 23-valent pneumococcal polysaccharide vaccine (PPSV23) at least 1 year after PCV13; if PPSV23 was previously administered but not PCV13, administer PCV13 at least 1 year after PPSV23
- When both PCV13 and PPSV23 are indicated, administer PCV13 first (PCV13 and PPSV23 should not be administered during the same visit); additional information on vaccine timing is available at www.cdc.gov/vaccines/vpd/pneumo/downloads/pneumo-vaccine-timing.pdf

Special populations

- Administer to adults aged 19 through 64 years with the following chronic conditions 1 dose of PPSV23 (at age 65 years or older, administer 1 dose of PCV13, if not previously received, and another dose of PPSV23 at least 1 year after PCV13 and at least 5 years after PPSV23):
  - **Chronic heart disease** (excluding hypertension)
  - **Chronic lung disease**
  - **Chronic liver disease**
  - **Alcoholism**
  - **Diabetes mellitus**
  - **Cigarette smoking**
- Administer to adults aged 19 years or older with the following indications 1 dose of PCV13 followed by 1 dose of PPSV23 at least 8 weeks after PCV13, and a second dose of PPSV23 at least 5 years after the first dose of PPSV23 (if the most recent dose of PPSV23 was administered before age 65 years, at age 65 years or older, administer another dose of PPSV23 at least 5 years after the last dose of PPSV23):
  - **Immunodeficiency disorders (**including B- and T-lymphocyte deficiency, complement deficiencies, and phagocytic disorders)
  - **HIV infection**
  - **Anatomical or functional asplenia (**including sickle cell disease and other hemoglobinopathies)
  - **Chronic renal failure and nephrotic syndrome**
- Administer to adults aged 19 years or older with the following indications 1 dose of PCV13 followed by 1 dose of PPSV23 at least 8 weeks after PCV13 (if the dose of PPSV23 was administered before age 65 years, at age 65 years or older, administer another dose of PPSV23 at least 5 years after the last dose of PPSV23):
  - **Cerebrospinal fluid leak**
  - **Cochlear implant**

8. Hepatitis A vaccination

www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hepa.html

General information

- Administer to adults who have a specific risk (see below), or lack a risk factor but want protection, 2-dose series of single antigen hepatitis A vaccine (HepA; Havrix at 0 and 6–12 months or Vaqta at 0 and 6–18 months; minimum interval: 6 months) or a 3-dose series of combined hepatitis A and hepatitis B vaccine (HepA-HepB) at 0, 1, and 6 months; minimum intervals: 4 weeks between first and second doses, 5 months between second and third doses

Special populations

- Administer HepA or HepA-HepB to adults with the following indications:
  - **Travel** to or work in countries with high or intermediate hepatitis A endemicity
  - **Men who have sex with men**
  - **Injection or noninjection drug use**
  - **Work with hepatitis A virus in a research laboratory or with nonhuman primates infected with hepatitis A virus**
  - **Clotting factor disorders**
  - **Chronic liver disease**
  - Close, personal **contact with an international adoptee** (e.g., household or regular babysitting) during the first 60 days after arrival in the United States from a country with high or intermediate endemicity (administer the first dose as soon as the adoption is planned)
  - Healthy adults **through age 40 years who have recently been exposed to hepatitis A virus**; adults older than age 40 years may receive HepA if hepatitis A immunoglobulin cannot be obtained

9. Hepatitis B vaccination

www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hepb.html

General information

- Administer to adults who have a specific risk (see below), or lack a risk factor but want protection, 3-dose series of single antigen hepatitis B vaccine (HepB) or combined hepatitis A and hepatitis B vaccine (HepA-HepB) at 0, 1, and 6 months (minimum intervals: 4 weeks between doses 1 and 2 for HepB and HepA-HepB; between doses 2 and 3, 8 weeks for HepB and 5 months for HepA-HepB)

Special populations

- Administer HepB or HepA-HepB to adults with the following indications:
  - **Chronic liver disease** (e.g., hepatitis C infection, cirrhosis, fatty liver disease, alcoholic liver disease, autoimmune hepatitis, alanine aminotransferase [ALT] or aspartate aminotransferase [AST] level greater than twice the upper limit of normal)
  - **HIV infection**
  - **Percutaneous or mucosal risk of exposure to blood** (e.g., **household contacts** of hepatitis B surface antigen [HBsAg]-positive persons; adults younger than age 60 years with **diabetes mellitus** or aged 60 years or older with diabetes mellitus based on individual clinical decision; adults in predialysis care or receiving **hemodialysis or peritoneal dialysis**; recent or current **injection drug users**; **health care and public safety workers** at risk for exposure to blood or blood-contaminated body fluids)
  - **Sexual exposure risk** (e.g., sex partners of HBsAg-positive persons; sexually active persons not in a mutually monogamous relationship; persons seeking evaluation or treatment for a sexually transmitted infection; and **men who have sex with men** [MSM])
  - Receive care in **settings where a high proportion of adults have risks for hepatitis B infection** (e.g., facilities providing sexually transmitted disease treatment, drug-abuse treatment and prevention services, hemodialysis and end-stage renal disease programs, institutions for developmentally disabled persons, health care settings targeting services to injection drug users or MSM, HIV testing and treatment facilities, and correctional facilities)
  - **Travel** to countries with high or intermediate hepatitis B endemicity

10. Meningococcal vaccination

www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html

Special populations: Serogroups A, C, W, and Y meningococcal vaccine (MenACWY)

- Administer 2 doses of MenACWY at least 8 weeks apart and revaccinate with 1 dose of MenACWY every 5 years, if the risk remains, to adults with the following indications:
  - **Anatomical or functional asplenia (**including sickle cell disease and other hemoglobinopathies)
  - **HIV infection**
  - **Persistent complement component deficiency**
  - **Eculizumab use**
- Administer 1 dose of MenACWY and revaccinate with 1 dose of MenACWY every 5 years, if the risk remains, to adults with the following indications:
  - **Travel to or live in countries where meningococcal disease is hyperendemic or epidemic**, including countries in the African meningitis belt or during the Hajj
  - At risk from a **meningococcal disease outbreak attributed to serogroup A, C, W, or Y**
  - **Microbiologists** routinely exposed to *Neisseria meningitidis*
  - **Military recruits**
  - **First-year college students who live in residential housing** (if they did not receive MenACWY at age 16 years or older)

General Information: Serogroup B meningococcal vaccine (MenB)

- May administer, based on individual clinical decision, to young adults and adolescents aged 16–23 years (preferred age is 16–18 years) who are not at increased risk 2-dose series of MenB-4C (Bexsero) at least 1 month apart or 2-dose series of MenB-FHbp (Trumenba) at least 6 months apart
- MenB-4C and MenB-FHbp are not interchangeable

Special populations: MenB

- Administer 2-dose series of MenB-4C at least 1 month apart or 3-dose series of MenB-FHbp at 0, 1–2, and 6 months to adults with the following indications:
  - **Anatomical or functional asplenia** (including sickle cell disease)
  - **Persistent complement component deficiency**
  - **Eculizumab use**
  - At risk from a **meningococcal disease outbreak attributed to serogroup B**
  - **Microbiologists** routinely exposed to *Neisseria meningitidis*

11. *Haemophilus influenzae* type b vaccination

www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hib.html

Special populations

- Administer *Haemophilus influenzae* type b vaccine (Hib) to adults with the following indications:
  - **Anatomical or functional asplenia** (including sickle cell disease) or undergoing elective splenectomy: Administer 1 dose if not previously vaccinated (preferably at least 14 days before elective splenectomy)
  - **Hematopoietic stem cell transplant** (HSCT): Administer 3-dose series with doses 4 weeks apart starting 6 to 12 months after successful transplant regardless of Hib vaccination history

Table. Contraindications and precautions for vaccines recommended for adults aged 19 years or older*

The Advisory Committee on Immunization Practices (ACIP) recommendations and package inserts for vaccines provide information on contraindications and precautions related to vaccines. Contraindications are conditions that increase chances of a serious adverse reaction in vaccine recipients and the vaccine should not be administered when a contraindication is present. Precautions should be reviewed for potential risks and benefits for vaccine recipients.

Contraindications and precautions for vaccines routinely recommended for adults

Vaccine(s)	Contraindications	Precautions
All vaccines routinely recommended for adults	• Severe reaction, e.g., anaphylaxis, after a previous dose or to a vaccine component	• Moderate or severe acute illness with or without fever

Additional contraindications and precautions for vaccines routinely recommended for adults

Vaccine(s)	Additional Contraindications	Additional Precautions
IIV[1]		• History of Guillain-Barré syndrome within 6 weeks after previous influenza vaccination • Egg allergy other than hives, e.g., angioedema, respiratory distress, lightheadedness, or recurrent emesis; or required epinephrine or another emergency medical intervention (IIV may be administered in an inpatient or outpatient medical setting and under the supervision of a health care provider who is able to recognize and manage severe allergic conditions)
RIV[1]		• History of Guillain-Barré syndrome within 6 weeks after previous influenza vaccination
Tdap, Td	• For pertussis-containing vaccines: encephalopathy, e.g., coma, decreased level of consciousness, or prolonged seizures, not attributable to another identifiable cause within 7 days of administration of a previous dose of a vaccine containing tetanus or diphtheria toxoid or acellular pertussis	• Guillain-Barré syndrome within 6 weeks after a previous dose of tetanus toxoid-containing vaccine • History of Arthus-type hypersensitivity reactions after a previous dose of tetanus or diphtheria toxoid-containing vaccine. Defer vaccination until at least 10 years have elapsed since the last tetanus toxoid-containing vaccine • For pertussis-containing vaccine, progressive or unstable neurologic disorder, uncontrolled seizures, or progressive encephalopathy (until a treatment regimen has been established and the condition has stabilized)
MMR[2]	• Severe immunodeficiency, e.g., hematologic and solid tumors, chemotherapy, congenital immunodeficiency or long-term immunosuppressive therapy[3], human immunodeficiency virus (HIV) infection with severe immunocompromise • Pregnancy	• Recent (within 11 months) receipt of antibody-containing blood product (specific interval depends on product)[4] • History of thrombocytopenia or thrombocytopenic purpura • Need for tuberculin skin testing[5]
VAR[2]	• Severe immunodeficiency, e.g., hematologic and solid tumors, chemotherapy, congenital immunodeficiency or long-term immunosuppressive therapy[3], HIV infection with severe immunocompromise • Pregnancy	• Recent (within 11 months) receipt of antibody-containing blood product (specific interval depends on product)[4] • Receipt of specific antiviral drugs (acyclovir, famciclovir, or valacyclovir) 24 hours before vaccination (avoid use of these antiviral drugs for 14 days after vaccination)
ZVL[2]	• Severe immunodeficiency, e.g., hematologic and solid tumors, chemotherapy, congenital immunodeficiency or long-term immunosuppressive therapy[3], HIV infection with severe immunocompromise • Pregnancy	• Receipt of specific antiviral drugs (acyclovir, famciclovir, or valacyclovir) 24 hours before vaccination (avoid use of these antiviral drugs for 14 days after vaccination)
HPV vaccine		• Pregnancy
PCV13	• Severe allergic reaction to any vaccine containing diphtheria toxoid	

1. For additional information on use of influenza vaccines among persons with egg allergy, see: CDC. Prevention and control of seasonal influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices—United States, 2016–17 influenza season. MMWR. 2016;65(RR-5):1–54. Available at www.cdc.gov/mmwr/volumes/65/rr/rr6505a1.htm.
2. MMR may be administered together with VAR or ZVL on the same day. If not administered on the same day, separate live vaccines by at least 28 days.
3. Immunosuppressive steroid dose is considered to be daily receipt of 20 mg or more prednisone or equivalent for 2 or more weeks. Vaccination should be deferred for at least 1 month after discontinuation of immunosuppressive steroid therapy. Providers should consult ACIP recommendations for complete information on the use of specific live vaccines among persons on immune-suppressing medications or with immune suppression because of other reasons.
4. Vaccine should be deferred for the appropriate interval if replacement immune globulin products are being administered. See: Best practices guidance of the Advisory Committee on Immunization Practices (ACIP). Available at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html.
5. Measles vaccination may temporarily suppress tuberculin reactivity. Measles-containing vaccine may be administered on the same day as tuberculin skin testing, or should be postponed for at least 4 weeks after vaccination.

* Adapted from: CDC. Table 6. Contraindications and precautions to commonly used vaccines. General recommendations on immunization: recommendations of the Advisory Committee on Immunization Practices. MMWR. 2011;60(No. RR-2):40–1 and from: Hamborsky J, Kroger A, Wolfe S, eds. Appendix A. Epidemiology and prevention of vaccine preventable diseases. 13th ed. Washington, DC: Public Health Foundation, 2015. Available at www.cdc.gov/vaccines/pubs/pinkbook/index.html.

Abbreviations of vaccines

IIV	inactivated influenza vaccine	VAR	varicella vaccine	HepA	hepatitis A vaccine
RIV	recombinant influenza vaccine	RZV	recombinant zoster vaccine	HepA-HepB	hepatitis A and hepatitis B vaccines
Tdap	tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine	ZVL	zoster vaccine live	HepB	hepatitis B vaccine
		HPV vaccine	human papillomavirus vaccine	MenACWY	serogroups A, C, W, and Y meningococcal vaccine
Td	tetanus and diphtheria toxoids	PCV13	13-valent pneumococcal conjugate vaccine	MenB	serogroup B meningococcal vaccine
MMR	measles, mumps, and rubella vaccine	PPSV23	23-valent pneumococcal polysaccharide vaccine	Hib	*Haemophilus influenzae* type b vaccine

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Pneumococcal Vaccine Timing for Adults

Make sure your patients are up to date with pneumococcal vaccination.

Two pneumococcal vaccines are recommended for adults:
- 13-valent pneumococcal conjugate vaccine (PCV13, Prevnar13®)
- 23-valent pneumococcal polysaccharide vaccine (PPSV23, Pneumovax®23)

PCV13 and PPSV23 should not be administered during the same office visit.

When both are indicated, PCV13 should be given before PPSV23 whenever possible.

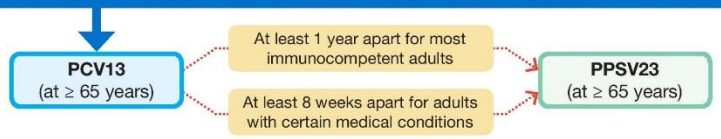
If either vaccine is inadvertently given earlier than the recommended window, do not repeat the dose.

One dose of PCV13 is recommended for adults:
- 65 years or older who have not previously received PCV13.
- 19 years or older with certain medical conditions and who have not previously received PCV13. *See Table 1 for specific guidance.*

One dose of PPSV23 is recommended for adults:
- 65 years or older, regardless of previous history of vaccination with pneumococcal vaccines.
  - Once a dose of PPSV23 is given at age 65 years or older, no additional doses of PPSV23 should be administered.
- 19 through 64 years with certain medical conditions.
  - A second dose may be indicated depending on the medical condition. *See Table 1 for specific guidance.*

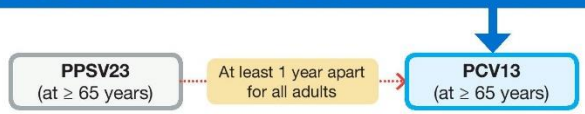
Pneumococcal vaccine timing for adults 65 years or older

For those who have not received any pneumococcal vaccines, or those with unknown vaccination history



- Administer 1 dose of PCV13.
- Administer 1 dose of PPSV23 **at least 1 year** later for most immuno*competent* adults or **at least 8 weeks** later for adults with immuno*compromising* conditions, cerebrospinal fluid leaks, or cochlear implants. *See Table 1 for specific guidance.*

For those who have previously received 1 dose of PPSV23 at ≥ 65 years and no doses of PCV13



- Administer 1 dose of PCV13 **at least 1 year** after the dose of PPSV23 for all adults, regardless of medical conditions.

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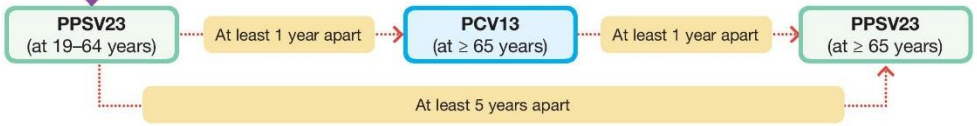
www.cdc.gov/pneumococcal/vaccination.html

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Pneumococcal vaccine timing for adults with certain medical conditions

Indicated to receive 1 dose of PPSV23 at 19 through 64 years



Includes adults with:

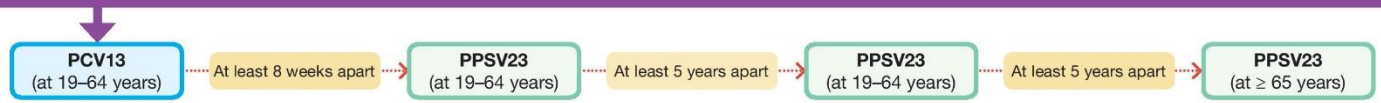
- chronic heart or lung disease
- diabetes mellitus
- alcoholism
- chronic liver disease

Also includes adults who smoke cigarettes

For those who have **not** received any pneumococcal vaccines, or those with unknown vaccination history:

- Administer 1 dose of PPSV23 at 19 through 64 years.
- Administer 1 dose of PCV13 at 65 years or older. This dose should be given **at least 1 year** after PPSV23.
- Administer 1 final dose of PPSV23 at 65 years or older. This dose should be given **at least 1 year** after PCV13 and at least 5 years after the most recent dose of PPSV23.

Indicated to receive 1 dose of PCV13 at ≥ 19 years and 1 or 2 doses of PPSV23 at 19 through 64 years



Includes adults with:

- cerebrospinal fluid (CSF) leaks*
- cochlear implants*
- sickle cell disease or other hemoglobinopathies
- congenital or acquired asplenia
- congenital or acquired immunodeficiencies
- HIV infection
- chronic renal failure
- nephrotic syndrome
- leukemia
- lymphoma
- Hodgkin disease
- generalized malignancy
- iatrogenic immunosuppression
- solid organ transplant
- multiple myeloma

For those who have **not** received any pneumococcal vaccines, or those with unknown vaccination history:

- Administer 1 dose of PCV13.
- Administer 1 dose of PPSV23 **at least 8 weeks** later.
- Administer a second dose of PPSV23 **at least 5 years** after the previous dose (**note: a second dose is not indicated for those with CSF leaks or cochlear implants*).
- Administer 1 final dose of PPSV23 at 65 years or older. This dose should be given **at least 5 years** after the most recent dose of PPSV23.

Table 1. Medical conditions or other indications for administration of PCV13 and PPSV23 for adults

Medical indication	Underlying medical condition	PCV13 for ≥ 19 years	PPSV23* for 19 through 64 years		PCV13 at ≥ 65 years	PPSV23 at ≥ 65 years
		Recommended	Recommended	Revaccination	Recommended	Recommended
None	None of the below				✓	✓ ≥ 1 year after PCV13
Immunocompetent persons	Alcoholism		✓		✓	✓ ≥ 1 year after PCV13 ≥ 5 years after any PPSV23 at < 65 years
	Chronic heart disease†					
	Chronic liver disease					
	Chronic lung disease§					
	Cigarette smoking					
	Diabetes mellitus					
	Cochlear implants	✓	✓ ≥ 8 weeks after PCV13		✓ If no previous PCV13 vaccination	✓ ≥ 8 weeks after PCV13 ≥ 5 years after any PPSV23 at < 65 years
	CSF leaks					
Persons with functional or anatomic asplenia	Congenital or acquired asplenia	✓	✓ ≥ 8 weeks after PCV13	✓ ≥ 5 years after first dose PPSV23	✓ If no previous PCV13 vaccination	✓ ≥ 8 weeks after PCV13 ≥ 5 years after any PPSV23 at < 65 years
	Sickle cell disease/other hemoglobinopathies					
Immunocompromised persons	Chronic renal failure	✓	✓ ≥ 8 weeks after PCV13	✓ ≥ 5 years after first dose PPSV23	✓ If no previous PCV13 vaccination	✓ ≥ 8 weeks after PCV13 ≥ 5 years after any PPSV23 at < 65 years
	Congenital or acquired immunodeficiencies¶					
	Generalized malignancy					
	HIV infection					
	Hodgkin disease					
	Iatrogenic immunosuppression‡					
	Leukemia					
	Lymphoma					
	Multiple myeloma					
	Nephrotic syndrome					
	Solid organ transplant					

*This PPSV23 column only refers to adults 19 through 64 years of age. All adults 65 years of age or older should receive one dose of PPSV23 5 or more years after any prior dose of PPSV23, regardless of previous history of vaccination with pneumococcal vaccine. No additional doses of PPSV23 should be administered following the dose administered at 65 years of age or older.

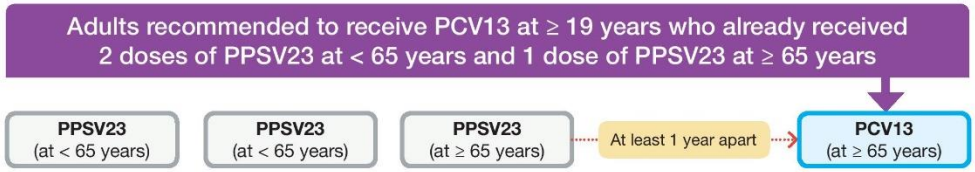
†Including congestive heart failure and cardiomyopathies

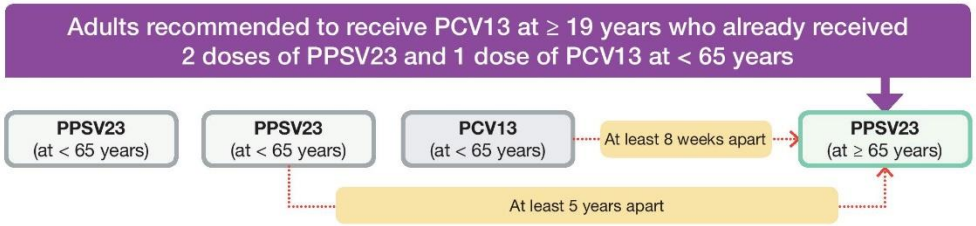
§Including chronic obstructive pulmonary disease, emphysema, and asthma

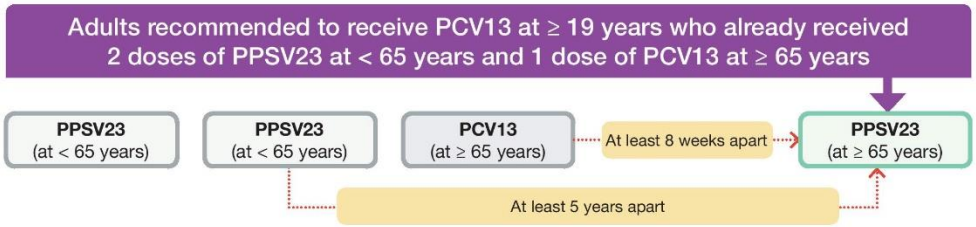
¶Includes B- (humoral) or T-lymphocyte deficiency, complement deficiencies (particularly C1, C2, C3, and C4 deficiencies), and phagocytic disorders (excluding chronic granulomatous disease)

‡Diseases requiring treatment with immunosuppressive drugs, including long-term systemic corticosteroids and radiation therapy

Additional scenarios: completing the pneumococcal vaccination series for adults







- For those who have already received 1 or more doses of PPSV23, or those with unclear documentation of the type of pneumococcal vaccine received:
  - Administer 1 dose of PCV13 **at least 1 year** after the most recent pneumococcal vaccine dose.
  - Administer a second dose of PPSV23 **at least 8 weeks** after PCV13 and at least 5 years after the previous dose of PPSV23 (*note: a second dose is not indicated for those with CSF leaks or cochlear implants*).
  - Administer 1 final dose of PPSV23 at 65 years or older. This dose should be given **at least 5 years** after the most recent dose of PPSV23.
- For those who have already received 1 dose of PCV13, do not administer an additional dose at 65 years or older.