Pertussis in Ohio: A descriptive analysis of the 2010 Columbus outbreak and patterns of a reemerging childhood disease

Christopher Rohde
Wright State University - Main Campus

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Pertussis in Ohio: A descriptive analysis of the 2010 Columbus outbreak and patterns of a reemerging childhood disease

Christopher Rohde, M.D.
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Abstract:

Objective: In 2010, Columbus, Ohio experienced the largest outbreak of pertussis that it has had in the past 25 years. Similar outbreaks are occurring across the nation on an increasing basis. This descriptive study examines the 2010 outbreak and describes the demographics of the affected population. Comparison is made to previous and current pertussis incidence in Ohio and outbreaks elsewhere in the United States. Contributing factors to the increasing occurrence of pertussis outbreaks are discussed.

Methods: Raw data was obtained from the Columbus Public Health epidemiology department and is gathered through the Ohio Disease Reporting System (ODRS). Pertussis cases are those which have occurred in Franklin County, Ohio and Columbus, Ohio as reported by local physicians’ offices and hospitals. Information on the disease and recent trends was obtained from multiple journal articles and the CDC website as well as from personal communication with members of the epidemiology staff at Columbus Public Health.

Results: Raw data is analyzed in the form of charts and graphs and comparison is made between groups by age and race. Analysis of recent literature supports a trend toward increasing pertussis incidence nationwide with more significant outbreaks, most likely as a result of decreased vaccination compliance and waning of pertussis vaccine in adolescents and young adults. Review of current literature reveals several hypothesized contributing factors including increased surveillance, increased pertussis virulence, and false positive diagnostic tests, which may or may not be significant factors.

Conclusions: The Columbus outbreak is typical of a nationwide trend in pertussis. Pertussis outbreaks are on the rise despite fairly good overall immunization uptake. Physicians must be notified of current outbreaks to increase surveillance of at-risk populations. Parents must be given good information regarding immunizations and efforts must be expanded to decrease barriers to immunization. In addition, improved immunization education of providers and better surveillance must be implemented to maximize immunization coverage among children and adults. Providers become complacent; not considering pertussis as a diagnosis for many respiratory infections until public health authorities publicize outbreak information in the media. More consistent testing would give better data regarding baseline pertussis rates and outbreaks. A nationwide electronic record-keeping and tracking method should be developed to avoid “missed opportunities” to vaccinate patients. These systems improve providers ability to notify patients of due or overdue immunizations and negate the problem of lost shot records which are common occurrences.
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Introduction

Pertussis, also known as whooping cough, is an endemic disease in the United States and worldwide with periodic epidemics and frequent community outbreaks. In the past, prior to widespread use of the inactivated pertussis vaccine in the 1940’s, pertussis was a common respiratory disease that caused significant morbidity and mortality in the United States, primarily in children. Pertussis is caused by a number of species of *Bordetella* bacterium, but the most clinically significant and only species that requires reporting to state public health authorities is *Bordetella pertussis*. Each year in the United States, numerous persons are infected with pertussis and some will die from complications related to the disease. Between 2000 and 2008, 181 people died from pertussis in the United States, 92% were under 6 months of age (CDC website). Globally, pertussis is a much larger problem, with 30-50 million cases each year and around 300,000 annual deaths from the disease (CDC website), most of those in countries that do not routinely vaccinate. The population most at risk for mortality due to pertussis is infants less than 6 months of age, particularly those who have not received their initial series of Diphtheria Toxoid, Tetanus Toxoid, and Acellular Pertussis (DTaP) vaccines. The Advisory Committee on Immunization Practices (ACIP) recommends a four-dose series of DTaP at ages 2 months, 4 months, 6 months and 15 – 18 months (Policy Statement, 2010). Due to an increasing incidence of pertussis among adolescents, in 2005 ACIP recommended a booster with Tetanus Toxoid, Reduced Diphtheria Toxoid and Acellular Pertussis (Tdap) for adolescents between the ages of 11 – 18. Despite this, pertussis coverage in 2009 remained only 56% among adolescents and less than 6% among adults. Because of this, ACIP expanded its recommendations for Tdap to include a booster in children age 7-10 that have not previously been fully immunized for pertussis (MMWR, 2011). The acellular pertussis portion of the DTaP vaccine was added in the
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1940’s. Prior to then, there were “as many as 147,000 reported cases of pertussis in the United States each year, including about 8,000 deaths.” Pertussis reached a low in 1976 with only 1,010 reported cases. 9,477 cases were reported in 2010 in California alone (CDC website).

The recent outbreak in Franklin County, Ohio (which includes the city of Columbus), described in this report, began in June 2010 and resulted in 966 reported cases of pertussis by the end of 2010 with no deaths. It is not unusual for small pertussis outbreaks to occur each year with larger outbreaks every 3 to 4 years. Because pertussis is highly contagious and there is always a reservoir of susceptible children, whether they are underimmunized or subject to waning immunity such as occurs in adolescents, it is difficult to contain the disease. Typically, the outbreaks have started with the onset of school in September, but it is not entirely clear why more severe outbreaks occur in a cyclic nature. It is likely a combination of immunization patterns and surveillance patterns. The Columbus outbreak was not typical of previous patterns, starting earlier than usual, in June. It appeared that the outbreak would be short-lived with rates dropping in August, but after school began in September it regained momentum to a peak number of 186 cases reported in October 2010 and then recovering through December 2010 and January 2011. This is more than double the peak cases reported in recent years in the city of Columbus and Franklin County (see figure 1). Similar resurgences of this disease have occurred in other populations, most notably in California, where 9,477 cases of pertussis had been reported between January 1, 2010 and December 31, 2010, including 10 infant deaths. This is California’s “most cases reported in 65 years when 13,492 cases were reported in 1945 and the highest incidence in 52 years when a rate of 26.0 cases per 100,000 was reported in 1958” (California Department of Public Health website). Large outbreaks have occurred in Michigan, Illinois, and many other states in recent years. The purpose of this descriptive study is to
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examine the demographics of the recent outbreak in Franklin County, Ohio and to explore some of the hypothesized causes for this and other outbreaks in the United States in recent years. Overall rates of pertussis immunization, increased surveillance, increased pertussis virulence, and false positive diagnostic tests are all evaluated as possible contributing factors to the higher incidence of pertussis and the increasing frequency of significant outbreaks.

Figure 1. Epidemiologic curve of monthly pertussis cases in Columbus and Franklin County from January 2005 thru December 2010 showing the magnitude of the 2010 outbreak compared to other more typical outbreaks in recent years.

Literature Review

The literature is replete with information on pertussis, including a number of studies describing recent outbreaks. In one article by Schafer, Gillette, Hedberg and Cieslak (2006), they described an increased incidence of pertussis in adolescents and adults between 1993 and 2006 despite widespread immunization coverage, and supported recommendations for a booster in this age group. This recommendation had already been made by ACIP in March 2005 edition of Morbidity and Mortality Weekly Report (MMWR). This recommendation states that
adolescents, age 11-18, should receive a dose of Tdap in place of or in addition to a routine Tetanus Toxoid and Diphtheria Toxoid (Td) booster even if Td was given recently in order to boost resistance to pertussis among this population. In a December 2006 edition of MMWR, ACIP further recommended that all adults be given one dose of Tdap in place of a routine Td booster. Despite this, the CDC still estimates that adult (age > 18) coverage for pertussis has not risen significantly beyond the 5.9% calculated in 2008.

Judelsohn and Koslap-Petraco (2007) conducted a study to review the epidemiological trends in Pertussis in the United States. By analyzing the incidence of pertussis, they hoped to devise methods of decreasing its occurrence, which has been increasing over the last two decades. There were no participants in this study, which utilized public health data to perform a descriptive analysis of pertussis. The findings showed that pertussis cases have increased significantly, especially among adolescents, which accounted for 38% of the pertussis cases in the year studied (2004), compared to previous years. The authors attributed this finding to a combination of increased surveillance, better diagnostic capabilities, and waning immunization effect in adolescents. In addition to the medical impact of disease, they clarified the economic burden of pertussis, a factor which they used to support their recommendations. Finally, they briefly discussed the development of Boostrix® and Adacel®, Tdap vaccines developed for use in adolescents and adults (both developed and FDA approved in 2005). The authors suggested that educators, policy-makers, and nurses focus their efforts on immunization of adolescents, especially beginning at age 10-11, before they enter middle school. They posited that focusing on this group will capture the largest proportion of the at-risk population and decrease the pool of infected individuals that further the risk of spread to unimmunized infants, those at most risk of severe disease and death from pertussis. The authors also recommended increased use of
community/regional/state registries to better track immunizations to increase timely immunization rates by making the unimmunized population more visible. Since this article was written, many states including Ohio have introduced mandatory vaccination of adolescents before they enter middle school. Time will tell if this has the desired effect of reducing the incidence of pertussis.

As in previous pertussis outbreaks, a large number of cases in recent outbreaks occur in infants less than 6 months of age. Infants are more susceptible due to the fact that they do not receive their first dose of DTaP until 2 months of age and do not receive full benefit from the vaccine until they have received the third dose at 6 months. A very recent article by Kuehn (2010) describes current recommendations made by ACIP which strongly suggest that household contacts and caregivers, including parents, siblings, and grandparents of newborn infants receive Tdap. The recommendation goes on to include those whose vaccine history is unclear or individuals over 65 years old who care for children, even though Tdap has not been approved by the Food and Drug Administration (FDA) for that age group. Kuehn’s article also describes a resurgence of pertussis cases and outbreaks in the United States beginning around 2004.

The United States is not the only developed country seeing an increase in pertussis outbreaks. Similar outbreaks are described in England, Japan, the Netherlands, and other countries. One interesting study from the Netherlands proposes that an emerging strain of *Bordetella pertussis* has developed a novel allele which promotes increased production of a specific toxin, essentially making that strain more virulent in humans, which could account for the increase in outbreaks (Mooi, 2009). While their evidence suggests that the severity of infection is affected by the strain and that this variation may affect efficacy of vaccine in mouse models, there is not sufficient evidence that this is correlated with infectivity in humans,
especially since the Pertussis toxin that they investigated has little to do with how the immune system targets the bacteria in immunized persons. Perhaps the virulence is causing a higher rate of infectivity in under-immunized persons. Further investigation of this theory is needed to determine if virulence or strain of pertussis is a contributor to the increased outbreak incidence.

Poor vaccination compliance, missed immunizations and delayed immunizations may be a large factor in more frequent and larger-scale outbreaks around the United States. In fact, less than 8% of children had all age-appropriate vaccinations administered in compliance with current recommendations in one study of over 175,000 children enrolled to four well-respected HMO groups (Mell, 2005). Another study of children enrolled in the Oregon Health Plan showed that up to 47 percent of children were behind on recommended immunizations at some point before 24 months and record reviews showed that over half of those children had opportunities to be immunized that were “missed” by their physician (Robison, 2010).

Outbreaks of infectious diseases such as Measles, mumps, pertussis, and varicella continue to occur in the United States and account for approximately 500 deaths annually (not including influenza), most in unimmunized children or those who have not received all recommended doses of a vaccine series (CDC website). Fortunately, state-required immunization of children prior to entry into school has resulted in immunization rates of 90% and better for most childhood diseases by the age of 5 years. Unfortunately, up until school age, many children are inadequately vaccinated.

In the United States, while vaccination is “required” for children entering school, these rules are not enforceable and parents can request exemption from these policies in most states. There are many reasons why parents elect not to have their children immunized. Some choose not to immunize based on religious beliefs, a right that is guaranteed by our constitution. This
cause of non-immunization can be dangerous because it places larger populations of non-immunized children in close proximity to each other, essentially eliminating the herd immunity effect. A study by Feikin et al. (2000) showed that children whose parents choose to exempt them from immunization are 22 times more likely to acquire measles and 6 times more likely to acquire pertussis than immunized children. This same study found that schools with pertussis outbreaks had a significantly (p=0.001) higher percentage of “exemptors” than schools without outbreaks (4.3% vs. 1.5%).

Methodology

This report is a descriptive study which examines pertussis rates of infection in the United States and Ohio with a focus on the 2010 pertussis outbreak in Columbus, Ohio and Franklin County, Ohio. Raw data was obtained with assistance from the Columbus Public Health epidemiology department and is gathered through the Ohio Disease Reporting System (ODRS) and ODRS Extract, which provides archival data going back to 2001. All data was cleansed with removal of “non-cases” and duplicate data prior to calculation of statistical facts. Pertussis cases are those which have occurred in Franklin County and Columbus as reported by local physicians’ offices and hospitals to the Ohio Department of Health. Public Health area of responsibility for Columbus Public Health includes the cities of Columbus and Worthington. The remainder of Franklin County is under the jurisdiction of the Franklin County Board of Health. The data used in this report is a conglomerate of both groups. Information on the disease and recent trends was obtained from multiple journal articles and the CDC website as well as from personal communication with members of the epidemiology staff at Columbus Public Health.
**Case Definition**

Case definition includes suspected, probable or confirmed case of pertussis occurring in Columbus and Franklin County, Ohio. Pertussis can be divided into three stages, catarrhal, paroxysmal and convalescent. The catarrhal stage lasts 7 to 10 days and typically includes coryza (runny nose), low-grade fever, and mild cough. The paroxysmal stage lasts 1 to 6 weeks (some cases up to 10 weeks) and is characterized by severe paroxysms (bursts) of coughing which may or may not be accompanied by an inspiratory “whoop” or posttussive emesis. Apnea and cyanosis may be the only symptoms in infants who are at the highest risk of serious complications and death. The convalescent stage is a 1 to 3 week recovery stage during which the cough gradually subsides. The disease is highly communicable, especially during the first two weeks. The incubation period is 9-10 days with a range of 6-20 days.

There are three categories of diagnosis for the data in this report; Suspected, Probable, and Confirmed. Suspected cases are those reported as pertussis, but not meeting the case definition. Probable cases include those meeting the case definition for a clinical case, but without laboratory confirmation. Confirmed cases include those that have any of the following: 1) Cough AND a confirmatory bacterial culture, 2) Clinical diagnosis AND a positive polymerase chain reaction (PCR), or 3) Clinical diagnosis AND an epi-link to a lab-confirmed case.

**Results**

Case occurrence of pertussis in Columbus and Franklin County is consistent with most regions in the United States and can be characterized as endemic with intermittent mild epidemics and localized outbreaks (Fig. 1). However, cases of pertussis in Columbus and the local area have been steadily increasing over the last 10 years (Fig. 2). A previous significant
outbreak occurred in 2007, initially identified in a Worthington High School water polo team member. The majority of the 2007 outbreak cases (44 of 65) occurred in Thomas Worthington High School during the months of Oct-Nov 2007, making the outbreak source easily identified and localized (Columbus Public Health). A similar outbreak was described in Cincinnati in 1993, in which the authors noted a shift in incidence from a younger to an older group of children (median 6 months to median 17 months) when compared to the years 1979-1992. They also noted that 74% of those 19 months to 12 years old had received four or five doses of DTaP, leading them to conclude that the pertussis vaccine failed to give the children full protection from pertussis (Christie, 1994).

Figure 2. Epidemiologic curve of annual pertussis cases in Columbus and Franklin County from 2001 thru 2010, showing increasing trend in diagnosed pertussis cases.

The current outbreak, while having the highest incidence among infants, children and adolescents, does not appear to be associated with any specific area, school or demographic group. In Columbus, there were two significant school outbreaks in the spring, one sports team
cluster and several daycare clusters. Franklin County had several elementary school outbreaks with cases concentrated in a few grades, with third graders (8 year olds) being the most affected. The highest number of cases have been in the 10 to 19 year old age group (a large proportion of which is 10-13 year olds), suggesting waning of the childhood pertussis vaccination at this age (Fig. 3).

![Pertussis Cases by Age and Race/Ethnicity](image)

**Figure 3.** Pertussis case count by age group for Columbus and Franklin County from January 1 thru December 31, 2010.

The Columbus outbreak shows an unusually high incidence among the 2-4 year old age group (99 per 100,000 for white children) when compared to the national case rate (11 per 100,000). Additionally, incidence in Hispanics is 2.6 times that of white infants, consistent with national statistics. However, this may be skewed with such a small population of Hispanics in
the Columbus area and the small representative number of cases among Hispanics (5), but could reflect a lower rate of immunization among Hispanics or the tendency for this population to commune together.

When viewed by incidence, although the number of cases is smaller, the most affected age group is the <1 year old group. (Fig. 4) The majority of those cases are in children under 6 months old due to incomplete immunization in that group, but missed immunizations carry a higher incidence rate up to age 5 where the incidence drops due to mandatory school vaccination. The reason for the higher incidence among 3 year olds is not clear. The drop beyond age 15 likely represents a lower rate of diagnosis and not necessarily a lower rate of infection.

Figure 4. Pertussis incidence rates by age group for Columbus and Franklin County from January 1 thru October 23, 2010. Note that the incidence is highest among children less than 1 year, which contains a larger percentage of children with incomplete immunization, and 10 year olds, a population in which the pertussis vaccine is waning. As children are given Tdap boosters beginning at age 11, a decline in case numbers is seen.

Pertussis cases by racial category closely mirrors the composition of the population in Columbus and Franklin County with a couple of exceptions: Blacks account for a slightly lower
proportion of pertussis cases than would be expected and Hispanics, as previously stated have a proportionately higher incidence of infection. (Fig. 5)

According to Sema Mandal, MBBS, MPH, an epidemiologist and researcher from the CDC, who helped investigate the 2010 pertussis outbreak in Columbus, a similar outbreak in Durango, Colorado in 2009 was at least partially due to false positive PCR tests which are very sensitive to contaminants in clinics and hospital laboratories. Dr. Mandal and her team of epidemiologists spent nearly 2 weeks at Columbus Public Health (CPH) and while no published data has come from their investigation, they presented their findings in a closing meeting to the health commissioner and CPH staff members on December 20, 2011. In determining if the outbreak was “real” versus a “pseudo-outbreak”, researchers looked at PCR cycle times, or “Ct” values. A high Ct value indicates a smaller amount of DNA present, with the CDC designating a value of less than 35 positive, 35 to 40 indeterminate, and greater than 40 negative. National Children’s Hospital, where the majority of testing is done in Columbus, designates any value

Figure 5. Comparison of pertussis cases to population race composition showing higher incidence among Hispanics.
below 37 as positive. The mean Ct value in 2010 as of the time of the investigation was 29.9 (N=905), well within the positive range, suggesting that there were actual cases of pertussis occurring and this was not a pseudo-outbreak. Confirmatory serology was drawn from 14 cases for further evidence of infection. The results showed 5 of 14 (36%) of the overall cases were seropositive, including 4 of 7 (57%) “confirmed” cases (those with a positive PCR) and only 1 of 6 (17%) ”suspected” cases (reported as pertussis, but not meeting the case definition).

Limitations

Although there appears to be good immunization uptake within the Columbus-Franklin County population diagnosed with pertussis, somewhere around 90% (CDC epi-aid team), data is input into ODRS by a variety of sources and is not confirmed through medical record review. Reported vaccination completion from adult patients and parents of pediatric patients are subject to inaccurate recall. Not all data was completely recorded in ODRS and individuals were not contacted to attempt to complete the data. Incomplete data on some individuals included race, ethnicity, vaccination status and in a few instances date of birth and age. Individuals without a recorded race or ethnicity were grouped into “unknown/other” for purposes of demographics, although this could skew the calculations for those categories. The few individuals with no age or date of birth recorded were dropped from the data.

Comparison with a similar city in the region, such as Cincinnati or Cleveland should be made to determine if pertussis incidence is similar in like cities. However, reporting of data to ODRS in those cities is done differently than in Columbus so data could not be extracted in the exact same manner making comparison difficult. Also, control groups to compare to the infected population would be advised and although CPH infectious disease nurses attempted to recruit control participants, they were unable to enroll enough people for reasonable data collection.
Information taken from the CDC epidemiology team is preliminary, unpublished data and although is likely accurate, should not be published as factual until done so by the original source.

**Discussion/Conclusions**

Pertussis is not just a childhood infectious disease. It is also an adult disease that continues to pose a significant threat to our population. While children, especially infants are the most at risk for severe illness and death, it is adolescents and young adults that have recently been the populations with the highest number of infections. It is also the population that is most likely to go undiagnosed since symptoms are not as severe and less likely to be suspected as pertussis. For this reason, cases among adults are frequently underreported and likely much more common than is suggested by the demographic data. Data from this study demonstrate that the Columbus outbreak is no exception, with the highest number of cases in adolescents and young adults. The CDC has attempted to improve the pertussis immunization coverage among adolescents and adults by recommending Tdap to children at age 11 and replacing at least one Td booster with Tdap in adults. This method has not improved coverage as much as hoped based on data from a 2010 report from the CDC on pertussis coverage among adults. A more proactive approach must be implemented to reduce pertussis among this population. It is imperative that primary care providers improve their efforts to immunize their adolescent and adult patients at every opportunity. This will ultimately prove to be the most effective way to reduce exposure of infants-at-risk and reduce the morbidity and mortality associated with pertussis.

The increased incidence of large community outbreaks in recent years, including the 2010 Columbus outbreak, is likely the result of many factors. Chief among these are incomplete vaccination coverage because of insufficient doses (as in the <6 month population) and waning
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protection in the young adult population. These two demographic groups have the highest incidence rate and largest number of reported cases respectively of any group in the Columbus population. Over the last few decades, the reduced incidence of childhood vaccine-preventable diseases has given parents the false perception that these diseases are less severe or that their children are less susceptible to the diseases. During this same timeframe, increasing reports of vaccine side effects and associated diseases have become more prominent in the mainstream media. Although the majority of these claims have been disproved, the attitudes of parents have become one of mistrust and confusion about immunizations. During the period of 1991 to 2004, the average state rate of exemptions has increased from 0.98% to 1.48% (Omer, 2009). The rate has increased from 0.99% to 2.54% in those states that allow exemptions for philosophical reasons. While this number does not seem large, it represents a pool of children that are potentially at risk for disease and who could, if infected, transmit disease to infants who have not had complete immunization or other children who did not have a adequate immune response to vaccination to grant them full immunity. Physicians must focus their efforts on this group of parents to provide current, accurate information on vaccine safety and the risk of these potentially deadly diseases.

Another possible reason for the increase in pertussis cases could be increased surveillance and reporting among medical providers. When an outbreak occurs, providers are likely to receive epidemiologic data and guidance from their local health departments, making them more vigilant for potential pertussis cases. This is likely in the Columbus outbreak, where pertussis testing tripled from 3168 in 2009 to 9322 in 2010 while the percentage of positive results actually decreased from 14.1% to 9.6% (CDC unpublished data). Since pertussis symptoms often resemble other less severe respiratory viruses, especially in older children and adults, many
people go untested during non-outbreak periods, so it is likely that the baseline rate of pertussis is actually much higher than reported. Increased surveillance should be encouraged so a more accurate idea of the rate of pertussis can be obtained. This requires better education of providers regarding screening of immunizations during acute medical visits and increased vigilance during the fall and winter months for signs and symptoms of pertussis. By identifying more cases of pertussis, parents may be made aware of the increased risk of pertussis and in turn, may be more likely to be compliant with vaccine recommendations.

Additionally, failure of the vaccine to provide an appropriate immunologic response is a possibility, as was concluded in a 1993 report of an outbreak in Cincinnati, Ohio, in which vaccinated children were primarily infected (Christie, 1994). There are clearly some gaps in vaccine coverage since the majority of those infected in the Columbus outbreak report up-to-date vaccination coverage. That is not to say that pertussis vaccine is not beneficial. Certainly, those who are immunization-protected are less likely to become infected and, if they do become infected, are less likely to have severe disease. More likely, this is a result of poor immunization practices, including incomplete immunizations, non-immunization or waning of childhood immunization. The recent outbreak in Columbus is typical in terms of populations affected. Outbreaks continue to occur across the country despite the availability of an effective vaccine and good vaccine uptake. However, in order to decrease the incidence of pertussis and lessen the risks of outbreak, we need to maximize immunization coverage among our population, young and old. Effective strategies include formation of an immunization “cocoon” around family members of newborns, who are not fully protected until age 6 months when they have had the initial series of three DTaP immunizations and opportunistic immunization of children at all clinic appointments, including acute appointments and walk-ins.
State-mandated vaccination for school children has been the most effective policy to maximize coverage among the school-age population, but states must look careful at the policies to make sure there are not missed opportunities to improve coverage. The State of Ohio now requires a booster for children prior to entering the 7th grade in public schools; however, an accepted alternative is the Td (Tetanus, diphtheria) booster, which does not include the pertussis component. This policy oversight and the fact that this booster was not required prior to this year in Ohio and still is not required in many states, could be contributing to the increasing number of pertussis cases that are being seen nationwide over the past several years.

Compulsory boosters with TDaP at age 11 will decrease the risk to the adolescent population whose vaccine effectiveness is waning.

Finally, a nationwide or state/regional electronic system of immunization record-keeping and tracking needs to be developed not only for the protection of our population, but to provide improved data to epidemiologists regarding immunization compliance among those infected during community outbreaks. This type of a system would decrease the incidence of delayed and missed vaccinations. It would allow physicians to track immunization status at all appointments, and not just at routine preventive visits, avoiding “missed opportunities”.

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