Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

_____ _____

Signature Date

An Assessment of El Paso Physician Knowledge, Attitudes, and Practices Regarding the Clinical Management of Suspected Cases of Pertussis

By

Ian Everitt

Master of Public Health

Epidemiology

Dr. Saad Omer, M.B.B.S. M.P.H. Ph.D.

Committee Co-Chair

Dr. Walter Orenstein, M.D.

Committee Co-Chair

Dr. Miguel Escobedo, M.D. M.P.H.

Thesis Field Advisor

An Assessment of El Paso Physician Knowledge, Attitudes, and Practices Regarding the Clinical Management of Suspected Cases of Pertussis

By

Ian Everitt

B.S., University of North Carolina at Chapel Hill, 2013

Faculty Thesis Advisor: Dr. Saad Omer, M.B.B.S. M.P.H. Ph.D.

Faculty Thesis Advisor: Dr. Walter Orenstein, M.D.

An abstract of

a thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health in Epidemiology

2015

Abstract

An Assessment of El Paso Physician Knowledge, Attitudes, and Practices Regarding the Clinical Management of Suspected Cases of Pertussis

By Ian Everitt

Background and Significance: Despite an observed increase in the incidence of pertussis in the El Paso, Texas, there is little quantifiable data to characterize ongoing transmission of pertussis infection. The collection of data, conduction of epidemiologic surveillance, and implementation of public health action in the region is complicated by a variety of unique geopolitical, social, cultural, and economic challenges. There is concern that the collection and interpretation of pertussis case data is hampered by inappropriate confirmatory testing and inadequate case reporting among El Paso physicians who encounter suspected cases of pertussis. Because limited information exists regarding the association between pertussis-related knowledge and attitudes and subsequent pertussis clinical management and confirmatory testing practices, obtaining this information is vital to understanding the factors that influence diagnostic testing and timely reporting of notifiable disease in El Paso.

Methods: An assessment of knowledge, attitudes, and practices was distributed to 123 physicians in El Paso, Texas. Multivariate logistic regression was used to assess and quantify the extent to which physician knowledge of pertussis disease and clinical management predict pertussis diagnostic testing practices. Additional analyses were conducted to inform future interventions by determining other factors that impact physician behavior and identify existing gaps in pertussis-related knowledge.

Results: Better knowledge of pertussis case definitions and clinical management was not significantly associated with conducting appropriate tests to confirm pertussis infection. Physician specialty, clinical practice setting, and country of medical education were associated with pertussis testing practices, although inappropriate testing practices were prevalent even among physicians who had extensive experience diagnosing cases of pertussis infection.

Discussion and Conclusions: Increasing pertussis-related knowledge among El Paso physicians may be effective in promoting appropriate confirmatory testing of pertussis infection. Although testing behavior is more strongly associated with other factors such as clinical specialty and inpatient versus outpatient work settings, these factors are not amenable to change through intervention. Education is needed in all groups, although targeted interventions aimed at improving the utilization of PCR to confirm suspected cases of pertussis is especially needed for physicians of non-pediatric specialties, who may be less likely to suspect and diagnose pertussis infections.

An Assessment of El Paso Physician Knowledge, Attitudes, and Practices Regarding the Clinical Management of Suspected Cases of Pertussis

By

Ian Everitt

B.S., University of North Carolina at Chapel Hill, 2013

Faculty Thesis Advisor: Dr. Saad Omer, M.B.B.S. M.P.H. Ph.D.

Faculty Thesis Advisor: Dr. Walter Orenstein, M.D.

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health in Epidemiology

2015

Acknowledgements

First and foremost, I would like to thank my advisors for their assistance throughout this process. Dr. Miguel Escobedo was heavily involved with developing the research concept and hypotheses and provided extensive feedback and guidance throughout my time in El Paso, Texas. Drs. Walter Orenstein and Saad Omer were instrumental in providing comments and feedback during the preparation of this manuscript, as well as validating the methods of analysis.

A special thank you to Carla DeSisto for being an endless source of encouragement, feedback, and ideas, both in El Paso and during the subsequent manuscript preparation process. I would also like to thank our colleagues in the El Paso and Sand Diego Quarantine Stations at the Centers for Disease Control and Prevention for their help and ideas related to KAP survey design and pertussis expertise. An additional thank you to Robert Resendes and Fernando Gonzalez at the El Paso Department of Public Health for their support and help acquiring data for this project.

I would also like to acknowledge the Global Field Experiences Award Selection Committee for providing funding for this research, and Dr. John McGowan for his invaluable feedback in applying for this grant.

Finally, many thanks to my family and friends for their continued support throughout this process.

Table of Contents

INTRODUCTION

The United States-Mexico Border Region

The United States-Mexico border region is a unique and dynamic territory that shares a common culture, language, and health status across geopolitical boundaries. The border region is defined as an area stretching approximately 2,000 miles from California to Texas and reaching 100 kilometers to the north and south of the U.S.-Mexico border[1] that shares social, economic, and epidemiological characteristics but operates under different legal and political systems, health systems, and policies (Figure 1).

This binational region is rapidly growing, with a population of approximately 13 million that is projected to double by the year 2025, and spans four U.S. states and six Mexican states with 43 points of entry along the border and fifteen pairs of sister cities. The U.S.-Mexico border is also recognized as one of the busiest international boundaries in the world, with over 800,000 people legally crossing into the United States from Mexico every day[2].

In addition to overseeing legal border crossings, U.S. Customs and Border Protection (CBP) is also responsible for preventing un-authorized entry into the United States across the U.S.-Mexico border. While overall border apprehensions have recently reached historically low levels, beginning in Fiscal Year 2014 the United States Customs and Border Protection noticed a drastic increase in the detection of unaccompanied minors and family units along the U.S.-Mexico border, largely originating in Central America, which has contributed to unique processing and administrative challenges in the region[3].

The significant mobility of this population, in combination with its unique cultural, social, and health characteristics makes it different from the rest of the United States and Mexico. It is therefore more appropriate to define the area along the U.S.-Mexico border as a

single binational region rather than two distinct sub-regions. The area is characterized by economically intertwined communities on both sides of the U.S.-Mexico border, binational familial ties among residents, and strong social networks on both sides of the border that create vibrant communities straddling the border and result in millions of daily legal crossings. This social dynamic requires effective collaboration between local and federal government agencies on both sides of the border to address complex policy issues surrounding health care as well as economic and social conditions[4].

The U.S.-Mexico border region faces pressing health and social conditions on both sides of the border. In Mexico, the northern border regions have better rates of vaccination coverage and certain prenatal outcomes than other regions of the country, although drug cartel-related violence, high rates of teen suicide, and elevated levels of substance abuse are of concern. In the United States, the region faces high rates of uninsurance, migration, inequitable health conditions, and a high rate of poverty. For example, 21 U.S. counties on the border have been designated as economically distressed areas, with three of the 10 poorest counties in the nation located in the border area. The unemployment rate along the U.S. side of the Texas-Mexico border is 2.5 to 3 times higher than the rest of the country, and communities along the Mexican side of the border are less likely to have access to basic water and sanitation services than the rest of the country due to rapid industrialization[2]. Furthermore, the U.S. Health Resources and Services Administration has claimed that if the U.S.-Mexico border region were to be made the 51st state then it would rank last in access to health care and per capita income, third in death rates due to diabetes, second in death rates due to hepatitis, and first in the number of children who are uninsured[5].

The border region poses a number of challenges to the Unites States healthcare system, partially by virtue of binational communities that operate under the health systems

and policies of both the United States and Mexico. Among the challenges are the region's rapidly growing population, diminished access to health care, a high incidence of avoidable health disparities, a lack of health coverage, and a shortage of health care professionals[4].

Population growth in the region has increased at a much faster rate than the United States as a whole. The four border states have accounted for more than one-third of the nation's population growth since 2000, and the population of the collective border counties has increased by 29.3 percent from 1990 to 2000[5]. In addition to being fast-growing, the population of the border region differs significantly in ethnic make-up from the rest of the United States. In 2013, 46.1% of the population in border counties was Hispanic, compared to 37.9% in the border states and 17.1% in the United States as a whole[6]. Twenty-six U.S. federally recognized indigenous tribes are also located alongside or straddling the border, composing five percent of the border population[4].

This rapidly growing segment of the population faces diminished access to health care as a result of socioeconomic vulnerabilities that can lead to poor health. Such vulnerabilities include persistent poverty, low educational achievement, high rates of unemployment, and the impact of rapid population growth. The socioeconomic gap between the border counties and the rest of the United States is the largest in the nation, with almost twice the rate of poverty and approximately three times the rate of unemployment as compared to the U.S. as a whole[7, 8].

As a result of these socioeconomic disparities, border residents suffer from a disproportionately high burden of many potentially avoidable infectious and chronic diseases. Childhood obesity and diabetes are reaching epidemic proportions in the border region[9, 10], while tuberculosis incidence is elevated as compared to the rest of the United States. Widespread poverty, frequent border crossings, and lack of coordinated care across

jurisdictions at the U.S.-Mexico border contribute to an elevated incidence of infectious diseases in the region[11]. The 2009 outbreak of H1N1 influenza virus was a stark global and binational lesson that diseases do not respect political borders; a novel swine-origin influenza A virus emerged in Veracruz, Mexico, in March or early April 2009, and within one year had spread to 213 countries and resulted in 600,000 laboratory-confirmed cases and at least 17,700 deaths[12]. Current concerns in the region include the establishment of dengue fever and chikungunya as locally acquired infectious diseases [13].

Residents in the border region also lead the nation in lack of health coverage. From 2000 to 2003, 23 percent of persons living in border states lacked health insurance, as compared to a national average of 14.7 percent[14]. Hispanics in border counties were significantly more likely than non-Hispanics to be without health coverage for more than one year[15]. Unable to afford the high cost of medical and dental services in the United States, many border residents seek care in Mexico for more affordable services. Ultimately, long-term disparities in insurance coverage result in inadequate access to health care services and significantly compromise health outcomes in the region.

The border region also suffers from a severe shortage of physicians, dentists, and health providers. For example, physicians per 10,000 population for all border counties is 16.3, compared to 26.2 in non-border counties in border states, and 26.1 for the U.S. as a whole[4]. The border region has fewer dentists, nurse practitioners, registered nurses, and pharmacists as compared to the rest of the United States. In addition, the under-representation of minorities in health professions affects the availability and quality of health care services for border residents. A shortage of linguistically and culturally competent providers is a barrier to health care access, negatively impacting communication and adherence to treatment[4, 16].

Despite the challenges facing the border region, the area can serve as a source for identifying innovative models that ensure collaboration among various levels of the government and private sector. Opportunities exist to improve health care access on the border, strengthen public health infrastructure, and promote evidence-based interventions to ensure that deliberate and sustained actions are taken to improve health conditions.

Health Challenges in the Paso del Norte Metropolitan Area

One of the largest metropolitan areas along the United States-Mexico border is the Paso del Norte region, located at the junction of the US states of Texas and New Mexico, and the Mexican state of Chihuahua. Centered on two large cities, Ciudad Juárez and El Paso, this region of 2.7 million people[17] is the second largest metropolitan area along the U.S.-Mexico border and the largest bilingual and binational workforce in the Western Hemisphere[18]. The region also includes the city of Las Cruces, which, with a population of over 100,000, is the second largest city in the state of New Mexico and the seat of Doña Ana County[19].

The City of El Paso, located on the U.S. side of the border in the state of Texas, has a rapidly growing population of approximately 673,000 as of 2012, up 3.6% from 2010[20]. An additional 150,000 people live outside El Paso city limits in El Paso County, yielding a total county population of approximately 828,000 as of 2013 estimates by the US Census Bureau[21]. Consistent with other areas of the border region, a majority of the population is of Hispanic ethnicity (80.7%), as compared to the state of Texas (37.6%) or the United States as a whole (17.1%)[6, 20]. According to the 2012 U.S. Census, a quarter of city residents report being foreign-born, while nearly three-quarters report speaking a language other than English at home[20].

Although it is difficult to quantify the binational nature of the Paso del Norte region,

the magnitude of the interconnectedness between the U.S. and Mexico becomes apparent when the number of border crossings is examined. In 2013 there were over 10.5 million non-commercial northbound legal vehicle crossings from Ciudad Juárez into El Paso, in conjunction with over 6 million legal pedestrian crossings and nearly 750,000 commercial vehicle crossings[22].

The city of El Paso faces many of the same health challenges as other border communities, particularly diminished access to health care and a lack of health coverage. El Paso has a population that is younger than the rest of Texas and the United States, with low educational attainment. Just 76% of residents age 25 or older are high school graduates, compared to 80% for the state of Texas and 85% for the entire U.S.[20, 23]. For the same age group, just 19% have a bachelor's degree compared to 30% nationally. El Paso County is among the poorest in the United States, with a median income of $36,333 compared to $51,914 for the United States as a whole. A lack of health insurance is readily apparent in El Paso County, where just 56% of residents reported having medical insurance in 2010, compared to 73% for the state of Texas and 82% for the entire country[23].

The cities of El Paso and Juárez effectively combine to serve as a single metropolitan area for the local community. From an epidemiologic perspective, the Paso del Norte population must therefore be considered a single entity, rather than different populations on two sides of a border. The high level of population movement, limited public health infrastructure, and poor environmental conditions also contribute to increased incidence of certain infectious diseases[24-26].

Pertussis Disease

The U.S. Centers for Disease Control and Prevention (CDC) has defined immunization against vaccine-preventable diseases as a 'winnable battle,' or a public health

priority with large-scale impact on health and with known, effective strategies to address them[27]. However, efforts by the United States public health community to eliminate or control vaccine-preventable diseases have been challenged by increased frequency of international travel and a growing skepticism of childhood vaccinations among certain segments of the public. Additionally, a lack of insight into the basis of protective immunity against disease and infection has hampered attempts to improve a number of vaccines and has led to concerns over possible re-emergence of infectious diseases[28, 29].

Analysis of data from the U.S. National Notifiable Diseases Surveillance System for 1990 through 1998 showed increased risks for certain vaccine-preventable diseases in U.S. counties within 100 kilometers of the border, compared with nonborder states. These data show a two- to fourfold greater incidence of hepatitis A, measles, rubella, and rabies in border counties than in nonborder states. Border counties also experience a higher incidence of pertussis relative to nonborder counties in border states[26].

Pertussis is an acute respiratory infection characterized by a severe, long-lasting cough that is caused by infection with the gram-negative *Bordetella pertussis* bacterium. Pertussis, also known as whooping cough, has a clinical case definition that is characterized by a cough illness lasting at least two weeks with one or more of the following: paroxysms of coughing, inspiratory whoop, post-tussive vomiting, or apnea in infants of less than one year of age[30]. Transmission occurs person-to-person through aerosolized droplets expelled during the coughing of an infected individual, and humans are the only known reservoir for pertussis[31].

The course of pertussis follows three general phases. Beginning with the catarrhal stage, pertussis has an insidious onset with nonspecific symptoms of upper respiratory infection and an irritating cough that over the course of 1-2 weeks becomes paroxysmal.

Paroxysms are characterized by repeated violent coughing; each paroxysm has many coughs without intervening inhalation and can be followed by a characteristic high-pitched inspiratory whoop. Such coughing fits often end with the expulsion of mucus and are followed by vomiting. The paroxysmal stage may last from 1-6 weeks before gradually resolving over the course of several months during the convalescent stage[31, 32].

Pertussis has historically been an important cause of morbidity and mortality and remains a significant cause of infant mortality worldwide. Serious complications or death are much more likely to occur among young infants than adolescents or adults. Potential complications resulting from pertussis infection may include pneumonia, pulmonary hypertension, seizures, encephalopathy, apnea, and death[32]. Between 20% and 50% of cases reported to CDC annually from 1992 through 2013 occurred in infants of less than one year of age, representing a significant burden to the healthcare system of the United States[33, 34].

Although the majority of reported cases and most significant complications occur in infants of less than one year of age, pertussis is also a common infection in adolescents and adults. Such infections are highly underreported by physicians[35-37]. In vaccinated individuals, the clinical severity is often reduced, and the characteristic whooping may be uncommon. However, such individuals are still contagious and capable of transmitting the bacteria to unimmunized or incompletely immunized individuals. In households with multiple pertussis cases, older persons are often the source of infection for children, and adults remain an important reservoir and source of infection for infants[30].

Pertussis Vaccination

Historical data suggest that the introduction of whole-cell pertussis vaccines in the 1950s significantly reduced disease burden. A series of four doses was shown to be 70-90%

effective at preventing serious pertussis disease. However, protection was shown to decrease with time, resulting in little or no protection 5 to 10 years after the last dose[30]. Although generally effective, whole cell vaccines are reactogenic[38], and concerns about safety led to the development of acellular vaccines associated with a lower frequency of adverse reactions[30].

The current pertussis vaccines in both the United States and Mexico are acellular and consist of purified, inactivated components of the bacteria, which are combined with diphtheria and tetanus toxoids into a single vaccine known as DTaP[39, 40]. There are currently two DTaP vaccines available in the United States, which are approved for children age 6 weeks through 6 years of age, while Mexico utilizes a four-dose, pentavalent acellular pertussis vaccine based on DTaP in combination with *Haemophilus influenza* type B and polio (DTaP-Hib-IPV)[39]. When studied, acellular DTaP vaccines were shown to have comparable short-term efficacy to the whole-cellular DTP vaccines, providing critical data to support the licensure of the acellular vaccines. Because of waning immunity documented with prior pertussis disease and whole cell vaccines, an adult and adolescent version of the vaccine (Tdap) was developed and has been introduced as a booster to immunizations received in childhood.

In the last decade, however, a growing number of highly vaccinated countries, including the United States, have reported an increasing trend in the general incidence of pertussis. This potential resurgence has raised serious concerns about the effectiveness of current pertussis vaccination strategies. The upsurge in reported incidence has led to the hypotheses that loss of immunity, in particular among recipients of acellular pertussis vaccines, has led to substantial accumulation of susceptible persons that results in outbreaks especially affecting older children and adolescents [38]. It has also been hypothesized that vaccination against pertussis may have a greater impact on the clinical severity of the disease

rather than the transmission of infection[41].

Accurate assessment of the duration of immunity after natural infection or vaccination is crucial for pertussis control, and yet our understanding of immunity to pertussis is limited. The central obstacle to the formulation of vaccines that confer long-lasting protection against pertussis is that despite a great deal of clinical research, no immune correlate of protection against pertussis has been identified[42].

Despite a limited understanding of pertussis immunity, high vaccination coverage remains necessary to significantly reduce the risk of pertussis disease. According to National Immunization Survey data compiled by the CDC, El Paso County experiences low acellular pertussis vaccine coverage relative to the rest of the state of Texas, with just 76.7% of children aged 19-35 months receiving at least four doses of DTaP vaccine in El Paso in 2013, compared to 81.4% of children in the rest of Texas. Nationally, 83.1% of children aged 19-35 months had received at least four doses of vaccine in 2013[43]. The proportion of children 19-35 months who had received at least four doses of DTaP in El Paso County has fallen from a high of 85.2% in 2003[44].

Across the border, pertussis vaccination coverage in Mexico has increased steadily since the 1980s, and as of 2008 coverage of the third dose of DTP vaccination (DTP3) was 98%. A sharp drop in coverage has occurred in recent years, down to 83% DTP3 coverage in 2013 according to WHO-UNICEF estimates[45]. While the decline in coverage is unexplained, it has been speculated that political unrest is a factor as drug and gang violence impact access to health services [46].

Pertussis Re-emergence in the United States

In the early 20th century United States, a high cumulative incidence and a fatality rate of 1 in 10 cases meant that pertussis killed more children annually than polio and measles

combined, and infection with *B. pertussis* was almost universal by the age of school entry. In 1943, the American Academy of Pediatrics recommended the routine use of whole-cell pertussis vaccine, and in 1948 the number of reported cases of pertussis in the United States dropped below 100,000 for the first time, while in 1976 just 1,000 cases of pertussis were reported [47].

However, beginning in the 1990s the whole cell pertussis vaccination was replaced with the acellular vaccine, and two important changes in the epidemiology of pertussis were observed. Beginning in the early 2000s an emergence of pertussis disease was observed among vaccinated adolescents, and more recently pertussis disease has emerged among school-aged children[47]. With the introduction of the Tdap booster for adolescents and adults, targeted use of the booster among adolescents aged 11 to 18 years old has been shown to preferentially reduce disease in this age group [48]. From 2006 to 2009, Tdap coverage among US adolescents increased from 10.8% to 55.6% and as of 2013 it has reached 86.0%, exceeding target levels [49, 50]. At the same time, however, the incidence among infants remained largely unchanged, suggesting limited herd immunity benefit from adolescent Tdap vaccination[48].

Recent outbreaks of pertussis in California[51] and Washington[52] resulted in an unusually large burden of disease for school-aged children of 7-10 years of age, many of whom were fully vaccinated with 5 doses of DTaP. These observations led to the hypothesis that recent pertussis epidemics were being driven largely by waning immunity and the redevelopment of susceptibility among children vaccinated with acellular vaccines, even in the face of recent booster doses[47].

In line with the rest of the United States, Texas has observed an increasing incidence of pertussis across all age groups between 2006 and 2013, with the incidence rate per

100,000 increasing three-fold and eight-fold among infants less than 1 year of age and children aged 10-14 years, respectively[53]. The trend of increasing incidence is mirrored in El Paso County, Texas. From 2006 to 2011, between 2 and 9 cases of pertussis were reported annually in El Paso County, corresponding to an annual incidence rate of 0.3-1.2 cases per 100,000 residents. However, 70 cases of pertussis were reported to the health department in 2012, and 65 cases in 2013, corresponding to incidence rates of 8.8 and 8.1 cases per 100,000 residents[53].

Very few cases of pertussis are reported across the border from El Paso, with just 4 cases reported in the state of Chihuahua in 2013, and 329 cases reported throughout the entire country of Mexico[54]. While it is likely that some degree of underreporting occurs in Mexico and that the impact of pertussis is higher than current data suggests[55], pertussis has not re-emerged in Mexico to the degree that it has in the United States, likely due to a very aggressive national vaccination program with a high degree of compliance.

However, in the United States, local, state, and federal public health organizations have little quantifiable data to characterize the nature of the ongoing pertussis epidemic beyond the sharp increase in incidence of pertussis. Such data is particularly difficult to ascertain in El Paso due to its position along the United States-Mexico border and the low-resource, binational nature of the region, which contributes several specific challenges to the collection of data, conduction of epidemiologic surveillance, and implementation of public health action.

Public Health Reporting of Pertussis in El Paso

As previously outlined, local, state, and federal public health organizations in El Paso have little quantifiable data to characterize the nature of pertussis transmission occurring with increasing frequency. To accurately characterize the increasing incidence of pertussis in

El Paso, implement meaningful policies, conduct accurate epidemiologic surveillance, and conduct an appropriate public health response, public health organizations rely heavily on physicians to quickly and accurately report cases of pertussis to the appropriate public health bodies. Despite this heavy reliance on public health reporting, cases of pertussis in El Paso are believed to be heavily underreported, in part due to existing barriers to health care access faced by the general population along the United States-Mexico border. Additional reasons for underreporting include failure to consider pertussis in the differential diagnosis of patients with cough and failure to confirm the diagnosis with the appropriate laboratory tests.

The state of Texas requires that all laboratory-confirmed and clinically-suspected cases of pertussis be reported to the local or regional health department or to the Texas Department of State Health Services (TX DSHS) Infectious Disease Control Unit within one business day[53]. Laboratory confirmation of pertussis infection for the purposes of public health reporting may only occur via the isolation of *B. pertussis* from a culture of a clinical specimen or via a positive polymerase chain reaction (PCR) assay[32].

Although isolation of the organism by culture is considered the gold standard for pertussis testing and is highly specific, the test is relatively insensitive and requires up to a week before results are available. Culture confirmation is recommended for pertussis outbreaks. The preferred laboratory test is PCR, which is rapid, sensitive, and specific, although it is not standardized across public health laboratories[56]. Both culture and PCR utilize a specimen collected via nasopharyngeal swab, which is gently inserted into the patient's nostril to the posterior nares, where a sample is obtained[32].

Serology is of limited use for the diagnosis of pertussis and is not considered confirmatory for the purposes of public health reporting because the ability of a patient to

demonstrate seroconversion may be affected by immunological priming by previous vaccination or infection[30, 57]. Current serologic tests in the United States have unproven or unknown clinical accuracy, although the CDC is actively engaged in better understanding the usefulness of commercially available assays[30]. In general, serologic tests are most useful for diagnosis in later phases of the disease, when antibody titers are at their highest[30], although they are still a poor substitute for culture or PCR. The highly transmissible nature of pertussis means that heavy reliance on serologic testing is more likely to result in increased contact between contagious patients and susceptible contacts. However, the blood specimen required for serologic testing is relatively easy to collect compared to a nasopharyngeal swab.

Currently the only state that permits serologic testing as part of a confirmatory test of pertussis is Massachusetts, although strict standards are in place. Serologic testing is only considered confirmatory if the testing is performed at the Massachusetts State Laboratory Institute (SLI), the patient is at least 11 years of age, the patient has had a cough for at least 14 days, and at least three years have passed since the patient has last been vaccinated with Tdap[58]. Given the requirements necessary for serologic testing to be considered confirmatory for the purposes of public health reporting, it remains unlikely that new developments serologic testing will replace culture or PCR as the preferred methods of pertussis case confirmation.

In addition to serologic testing, direct fluorescent antibody (DFA) testing of nasopharyngeal secretions is sometimes used to screen for pertussis, although these results may not be used to confirm a case of pertussis for reporting purposes due to variable specificity[33, 59].

Any case that meets the clinical case definition of pertussis but is not laboratory confirmed, either because the patient was not tested, tested negative by PCR or culture, or

was tested by serology or DFA, must be classified as a probable case unless it can be epidemiologically linked to a laboratory-confirmed case[32]. Because inappropriately-tested cases may not be included in counts of pertussis cases by the CDC, Texas Department of State Health Services (TX DSHS), or El Paso Department of Public Health (EP DPH), it remains important that physicians collect the appropriate specimen from clinically-suspected cases of pertussis and order the appropriate diagnostic test to be performed by commercial laboratories.

Research Justification and Significance

Statistics from the Texas Department of State Health Services illustrate that the incidence of pertussis is increasing substantially throughout Texas, and particularly in El Paso. However, such numbers are likely an underestimate as pertussis is believed to be heavily underreported for a number of reasons. In particular, anecdotal observations by the El Paso Department of Public Health suggest that some physicians continually run inappropriate diagnostic tests for pertussis, precluding the cases from being counted in public health surveillance efforts.

To better understand the process of diagnosing and reporting suspected and confirmed cases of pertussis by physicians, an assessment of El Paso physician knowledge, attitudes, and practices (KAP) was designed to assess clinician knowledge of pertussis disease and diagnostic practices, knowledge of pertussis reporting guidelines in the state of Texas, case reporting practices, and attitudes regarding pertussis case reporting. Obtaining this information is essential to understand the factors that influence diagnostic testing and timely reporting of notifiable diseases to the appropriate public health authorities in El Paso.

Specific Aims

1. To characterize the diagnostic and reporting practices of physicians in El Paso regarding suspected and confirmed cases of pertussis, and examine the factors that influence physician practices.
2. To determine whether public health reporting practices differ by state of knowledge about pertussis.
3. To facilitate development of an evidence-based intervention designed to increase knowledge and awareness of public health reporting among El Paso physicians

METHODS

Research Context

In light of a documented increase in the incidence of pertussis in El Paso, as well as throughout Texas and the United States as a whole, the United States-Mexico Unit of the CDC's Division of Global Migration and Quarantine, in conjunction with the EP DPH and TX DSHS Region 9/10 Office, has begun several projects with the goal of characterizing pertussis in El Paso. The studies will seek to characterize the knowledge, attitudes, and practices of rural community members as they relate to respiratory infection, as well as perceived barriers to receiving the DTaP vaccine, in an effort to develop future interventions and educational materials designed with the goal of increasing the uptake of the DTaP vaccine and improving community knowledge of pertussis and other common respiratory infections. The proposed study populations will include a sample of residents in central El Paso as well as residents of Fort Hancock, an impoverished and underserved border town on the outskirts of the El Paso metropolitan area. Surveys of Fort Hancock residents will be administered by *promotoras*, or bilingual community health workers, who have been trained by TX DSHS.

To complement the proposed studies, an assessment of physician knowledge, attitudes, and practices with regards to the diagnosis and public health reporting of pertussis was also developed. The study population included currently practicing physicians who were deemed likely to encounter and diagnose cases of pertussis, including family physicians, pediatricians, gynecologists, internists, otolaryngologists, and allergists. The study population was limited to physicians practicing in the central regions of El Paso (Figure 2) due to time and budgetary constraints.

KAP Assessment Tool Development

Knowledge, attitudes, and practices (KAP) surveys help identify knowledge gaps, behavioral patterns, and commonly-held beliefs in order to increase understanding of the issue and elucidate targets and themes for interventions[60]. They have been conducted in a number of settings, among various populations, and on a multitude of subjects. Multiple KAP surveys pertaining to pertussis have been conducted among health care providers[61-63]. However, the majority of these surveys have focused on pertussis immunization and few have focused on diagnostic and reporting practices. This assessment works to address a lack of information about factors that may influence the diagnostic testing and clinical management of pertussis by physicians. Evaluation of the knowledge, attitudes, and practices of physicians enrolled in the survey cohort will also facilitate the development of an educational intervention that addresses the appropriate laboratory tests necessary to confirm a suspected diagnosis of pertussis and the importance of notifying public health agencies of cases of notifiable disease in a timely manner.

The KAP assessment was developed in June 2014, using self-produced questions designed to address project-specific objectives. Pertussis knowledge was evaluated using survey questions regarding the length of naturally- and vaccine-acquired immunity, the clinical case definition, requirements to confirm suspected cases, and public health reporting requirements in the state of Texas. Attitudes were evaluated using questions about the seriousness of pertussis disease and the ease of reporting pertussis cases to the health department. Practices were evaluated using questions about clinical management practices, public health reporting, and confirmatory laboratory testing habits. Additional questions aimed at identifying key demographics of the providers and their patient pools were also

included. These included information on provider specialty and practice location, the age distribution of patients, and proxy measures of patient socioeconomic and binational status.

All questions designed to test knowledge of pertussis clinical management were created using the 2014 Epi Case Criteria Guide and the Guidelines for Investigation and Control of Invasive, Respiratory, Foodborne, and Vaccine-Preventable Diseases, both of which are published and maintained by the TX DSHS.

Feedback from subject matter experts and pilot test subjects was incorporated in editing of the KAP survey for clarity and brevity. The final assessment tool consisted of 30 questions and was designed to take no more than 15 minutes to complete.

A coding scheme, codebook, and files for data entry were developed using Microsoft Excel. Data was then analyzed using SAS 9.4 statistical software (Cary, N.C.).

Survey Administration and Data Collection

Physicians have frequently been a difficult group to survey, with generally low response rates to surveys despite the use of various delivery methods and incentives [64-69]. Because response rates are a concern among physicians, it was decided that hard copies of the assessment should be utilized, rather than online or email surveys. An information sheet containing an overview of the project printed on official Department of Public Health letterhead was also included with the assessment.

Using a database supplied by the El Paso Department of Public Health, an initial list of 118 office locations was identified as employing at least one eligible physician. Physicians were considered eligible to receive the survey if they had a business address located in central El Paso (defined in Figure 2) and a primary specialty of allergy/immunology, family medicine, general practice, infectious disease, internal medicine, obstetrics/gynecology, otolaryngology, or pediatrics. Physicians with a subspecialty listed were excluded.

In an effort to achieve the highest possible response rate, and to better track the number of physicians reached, paper copies of the assessment were delivered in-person to office managers at the 118 business addresses listed for eligible physicians. Each business address was visited in person by study staff and a packet containing copies of the assessment and an information sheet was delivered to the office staff. Of the 118 business addresses identified as eligible locations to distribute the survey, 71 were successfully contacted. Many of the remaining 47 addresses listed were residential addresses, or the practice had gone out of business or moved to a new location.

Surveys were distributed to all practicing physicians at each practice with the help of office staff, who were asked to collect completed surveys for collection by study staff at a later date. Office managers and physicians were sent reminders to complete the survey by email or phone every three to four days. Completed surveys were then collected by study staff approximately two weeks after the initial delivery of the survey.

Surveys were successfully distributed to 71 practices employing a total of 123 physicians. A total of 53 surveys were returned, corresponding to a response rate of 43%, of which 45 respondents were deemed eligible for inclusion in further data analysis. The remaining 8 respondents indicated that they did not currently treat or diagnose patients, or did not plan to continue to practice clinical medicine for at least one year post-survey.

Human subjects approval was not deemed necessary by the Emory University IRB, as the project did not collect any personal identifiable information and was considered a needs-based community assessment. Confidentiality was maintained throughout the project, and study staff did not know which physicians participated in the study.

Data Analysis

Analysis of the data on knowledge, attitudes, and practices of pertussis clinical management in the study population was conducted using SAS 9.4 (Cary, NC). Knowledge and attitude scores were calculated using previously published methods where available [70], while individual practices were dichotomized as "practitioners" for those who self-reported "always" or "usually" performing a given practice or as "non-practitioners" for those who "sometimes," "rarely," or "never" performed a given practice.

Bivariate analyses were conducted to examine factors associated with practices and with knowledge and attitude scores, along with other variables of interest identified during preliminary analyses. Pertussis testing practices were set as outcomes in multivariate logistic regression models in order to determine whether knowledge score was associated with a given practice and to quantify those associations.

Score Construction

Knowledge was assessed using a cumulative score where 1 point is awarded to correct answers and no points are given for incorrect or "don't know" answers, as outlined in Ho, et al. in 2013[70]. This is a fairly typical method of scoring knowledge in KAP surveys, and allowed for a maximum knowledge score of 25 points. Correct answers to knowledge questions were verified in the literature or according to published guidelines by the EP DPH or TX DSHS. The resulting knowledge score was then used to classify knowledge as "good," "fair," or "poor." Physicians with a knowledge score of 20 points or greater, corresponding to correct responses to at least 80% of questions, were classified as having "good" knowledge. Physicians with a knowledge score of 13 to 19 points, corresponding to a correct response rate of approximately 50-80%, were classified as having "fair" knowledge, while participants who correctly answered less than 50% of knowledge-

based questions, equivalent to a score of 12 or less, were classified as having "poor" knowledge.

Five questions assessing respondents' attitudes regarding the severity of pertussis disease, the significance of pertussis to the El Paso community, and the ease of reporting cases of pertussis to the appropriate public health authorities were included in the assessment, from which a single attitude score was derived. Questions were organized in a 5-step Likert scale from "strongly disagree" to "strongly agree" and points were assigned ranging from 0 points for "strongly disagree" to 4 points for "strongly agree," while neutral answers were awarded 2 points. One question was negatively quoted so that reverse scoring was used.

Three specific questions assessing respondent's self-reported frequency of conducting serologic testing to confirm pertussis diagnosis, conducting PCR or culture to confirm pertussis diagnosis, and reporting cases of pertussis to public health authorities in a timely manner were scored based on the frequency of behavior. Respondents who never performed a specified practice received a score of 0 points, while those who always performed a specific practice received a score of 4 points. The scores for individual practices were not summarized into an overall practice score.

Descriptive Statistics

We collected a variety of self-reported professional demographics from study participants, including how long respondents had been practicing medicine, in what country the respondent attended medical school, primary specialty, and practice settings. We also asked participants to estimate demographic characteristics of the patients that they treat, including proxy measures for patient socioeconomic status and "binational" status. Each physician was asked to estimate the proportion of their patients that either self-pays or

utilizes Medicaid in an effort to indirectly characterize the socioeconomic status of patients, while, similarly, respondents were asked to estimate how many patients live, work, or travel regularly to Mexico to better understand the mobility and binational character of physicians' patient populations.

In addition to self-reporting demographic information, we asked participants to provide information regarding their experience with pertussis, including the total number of cases of pertussis that each participant had diagnosed over the course of their careers. Physicians were also asked whether they felt that the annual incidence of pertussis had changed over the past five years, regardless of whether they had personally diagnosed any cases of pertussis

Descriptive statistics for self-reported information were calculated and reported as numbers and proportions for categorical variables. Where questions allowed a respondent to check multiple choices that apply, the value of the variable was set to missing and the participant was excluded from the analysis of that variable if none of the options were selected.

Bivariate Analyses

Physician experience with pertussis was further explored by examining whether the proportion of physicians who had diagnosed pertussis differed across various demographic characteristics using a chi-square goodness-of-fit test. In cases where a chi-square test may not have been valid due to cell counts of less than 5, Fisher's exact test was performed instead.

Pertussis knowledge and attitude scores were compared across various demographic characteristics using independent t-tests and one-way ANOVA. Scores for three pertussis-related behaviors were then analyzed by physician knowledge classification and demographic

characteristics using t-tests and one-way ANOVA. In cases where the distribution of the score was found to be significantly non-normal using the Kolmogrov-Smirnov goodness-of-fit test, the Wilcoxon-Mann-Whitney and Kruskal-Wallis H tests were utilized in place of the t-test and ANOVA, respectively. In cases where one-way ANOVA indicated significance between one or more levels, a Tukey post-hoc test was performed. In cases where a Kruskal-Wallis H test indicated significance between one or more levels, pairwise Wilcoxon-Mann-Whitney tests were conducted using a Bonferroni correction of the alpha level.

An alpha level of 0.05 was used to evaluate statistical significance for all analyses, with the exception of post-hoc testing following the Kruskal-Wallis H test. Marginally significant results (alpha level$\leq$0.1) were also reported when the association was considered plausible.

Multivariate Analyses and Model Construction

Multivariate maximum likelihood logistic regression models were constructed to further examine and quantify the extent to which pertussis knowledge predicts whether respondents order serologic testing to confirm pertussis diagnosis or order either polymerase-chain reaction (PCR) or bacterial culture to confirm pertussis diagnosis. Knowledge was included as categorical dummy variables rather than a continuous score to ease the interpretation of the odds ratio. All practice outcomes were dichotomized based on practice score. A practice score of 3.00 or greater, corresponding to "usually" or "always" performing the practice, was categorized as a "PCR tester," "serologic tester," or "pertussis case reporter," while scores below 3.00 were categorized as non-testers or non-reporters.

Variables included in the initial model as possible confounders consisted of physician demographic characteristics as well as additional characteristics that were found to be associated with the outcome in bivariate analyses. Eligible variables were assessed for

association with knowledge using t-tests and chi-square tests. The initial model used for assessment of collinearity, interaction, and confounding thus included the outcome of interest, the primary predictor, and eligible variables. Respondents with missing data for any of the variables included in the model were excluded from the corresponding analysis. The most appropriate final models were selected after consideration of collinearity, interaction, and confounding.

Collinearity, which can lead to unstable maximum likelihood estimates, was assessed prior to consideration of interaction or confounding. Condition indices and variance decomposition proportions (VDPs) were calculated. A potential collinearity problem was identified when at least one condition index was greater than thirty. Modeled variables with high VDPs (approximately 0.5) associated with such condition indices were eliminated from the model in order to minimize collinearity and ensure the accuracy of maximum likelihood estimates. Collinearity was continually reassessed to avoid unnecessary elimination and determine whether the removal was required. This was carried out sequentially until no further collinearity issues were evident.

Interaction was assessed following examination of the model for collinearity. Only two-factor interactions between the primary predictor and each variable in the initial model were considered. Hierarchical backward elimination was used to carry out the examination of interaction terms and the least significant interaction term was dropped from the full interaction model, resulting in a new reduced interaction model. This was continued until all interaction terms remaining in the model were significant (Wald chi-square test, $\alpha=0.05$). If there were no significant interaction terms remaining after backward elimination, it was concluded that there was no evidence of interaction in the model. Variables involved in any

significant interaction terms were retained in models during consideration of confounding to ensure that the final model was hierarchically well-formulated.

Following assessment of collinearity and interaction, any remaining variables not involved in a significant interaction were assessed for confounding. Evidence of confounding was present when the elimination of a potential confounder or group of confounders from the gold standard model, defined as the model including all potential confounders and significant interaction terms, resulted in a greater than 10% change in the estimated odds ratio for the primary predictor. All possible combinations of predictors were considered while retaining the primary predictor, any variables involved in interaction terms, and the interaction terms themselves. All models that yielded an odds ratio for the primary predictor within 10% of the gold standard odds ratio were eligible for further consideration. Of these models, the one with the greatest precision for the odds ratio for the effect of the primary predictor was selected as the best overall model.

All models of interest were examined in the manner described, resulting in hierarchically well-formulated final models that account for relevant interaction and confounding. These final models provide the most precise and accurate measure of the association between knowledge and the outcome of interest based on the data collected.

Exploring Additional Targets for Intervention

In the event that knowledge was not significantly associated with practices after accounting for interaction and confounding, multivariate logistic regression models were constructed to identify the factors most strongly associated with testing behaviors using existing methods[71]. A simple backward elimination procedure was implemented, allowing variables other than knowledge to become a part of the final model. The least significant term was eliminated from the model sequentially until all remaining terms were significant

(Wald chi-square test, α=0.05). While collinearity was addressed prior to backward elimination procedures, interaction and confounding were not assessed due to the lack of a previously-identified primary predictor. This procedure was used to build predictive models for pertussis testing using PCR or culture and using serology that were not restricted by the selection of knowledge score as the primary predictor.

RESULTS

Demographic Characteristics

Demographic information of eligible survey participants is summarized in Table 1. A total of 91.1% of respondents indicated that they worked in an outpatient setting, while nearly half (44.4%) worked in a hospital or inpatient setting. In addition to outpatient and inpatient clinical settings, a minority of respondents also indicated that they worked in clinical settings ranging from the emergency department or urgent care to intensive care units and community health centers.

Physicians were also asked how long they had been practicing medicine, excluding residency training, as well as their primary specialty and where they had received their medical education. Nearly half of respondents considered pediatrics to be their primary specialty, although a variety of specialties and subspecialties were indicated. Other specialties that were well represented included family and internal medicine, both indicated by 13.3% of respondents. As expected, physicians returning the survey primarily attended medical school in either the United States or Mexico (51.1% and 28.9%, respectively), although other countries represented included Cuba, El Salvador, India, and Bangladesh, among others.

Physicians were also asked to provide information regarding the demographics of their patients, also presented in Table 1. A plurality (44.5%) of respondents estimated that at least 30% of their patients paid for visits using Medicaid or self-payment. Patient mobility was estimated to be much more uniformly distributed, although again a plurality of respondents (31.8%) estimated that at least 30% of their patients regularly traveled to, or lived in, Mexico.

Physician Experience with Pertussis

Respondents' clinical experience with pertussis disease is summarized in Table 2. Half of all survey respondents indicated that they had diagnosed at least one case of pertussis during their careers, and over 10% of physicians had diagnosed six or more cases.

Among physicians who had directly encountered pertussis infection in their career, a plurality felt that the annual incidence had increased. However, many felt that the incidence had decreased or remained stable and there was no clear consensus among those who answered the question. Despite the fact that relatively few physicians with no direct pertussis experience answered the question, two thirds of respondents were not sure whether the annual incidence had changed over the past five years, possibly indicating a lack of familiarity with the status of pertussis in the region.

The association between pertussis experience and self-reported professional demographics is shown in Table 3. It was found that a significantly higher proportion of pediatricians had encountered pertussis relative to physicians of other specialties (Chi-square, $p<0.05$), which is not surprising given the disproportionate burden of pertussis-associated morbidity and mortality among young children and infants. We also found that length of time practicing medicine was marginally associated with the proportion of physicians who had encountered pertussis (Fisher's exact, $p<0.1$). Upon pairwise post hoc examination utilizing a Bonferroni correction, we determined that a greater proportion of physicians practicing medicine for at least 16 years had diagnosed at least one case of pertussis relative to those who had been practicing for shorter amounts of time (0-5 years).

Interestingly, the proportion of physicians who had encountered pertussis was significantly different based on where they had received their medical training (Fisher's exact, $p<0.05$). Upon pairwise post hoc examination utilizing a Bonferroni correction, a

significantly larger proportion of physicians who had attended medical school in Mexico had encountered a case of pertussis relative to physicians who had attended a U.S. medical school or other foreign medical school.

Pertussis Knowledge, Attitudes, and Practices: Descriptive Statistics

A total of five scores were calculated to summarize pertussis knowledge, attitudes, and practices among respondents. Knowledge scores are summarized in Tables 4 and 5, while attitude and practice scores are presented in Tables 6 and 7, respectively.

The average knowledge score for physicians was 14.64, with a standard deviation of 4.51, from a maximum possible score of 25. Deficits in knowledge were identified in several areas, including pertussis case definitions and symptoms, appropriate diagnostic testing procedures, and actions that public health authorities may take once a case has been reported. The number of correct responses by question are summarized in Table 4, with a breakdown of responses by answer choice where relevant.

Less than a quarter (22.2%) of respondents were able to correctly identify the minimum cough duration required to fit the TX DSHS pertussis case definition, and although most were able to correctly conclude that paroxysms of coughing and inspiratory "whoop" were possible signs of pertussis infection, little more than half indicated that they believed that nonspecific symptoms such as fever, apnea, or sneezing and runny nose could be associated with pertussis infection (66.7%, 61.5%, and 56.4%, respectively).

When presented with five scenarios describing various methods to confirm a suspected pertussis infection and asked to describe each scenario as appropriate or inappropriate to confirm pertussis infection according to Texas state guidelines, fewer than two-thirds of respondents were able to correctly identify whether any given method was confirmatory, and no respondent correctly identified all five scenarios as confirmatory or

non-confirmatory. Interestingly, nearly two-thirds of respondents (63.9%) incorrectly answered that clinical observation of a cough illness of two weeks duration with paroxysms of coughing, inspiratory whoop, or post-tussive vomiting was sufficient to diagnose a case of pertussis without additional laboratory testing. When asked what types of laboratory testing are confirmatory for the purposes of public health reporting, just over half of respondents (51.2%) were able to correctly indicate that serologic testing is not confirmatory of pertussis infection, while 73.2% of respondents felt that clinical judgment alone was sufficient to confirm pertussis infection.

Finally, it was determined that respondents generally had low levels of knowledge regarding the actions that the local health department can take once a case of pertussis has been reported. While a majority were able to correctly identify that the health department works to identify contacts at risk of exposure, little more than half of respondents knew that the health department keeps a tally of cases for statistical purposes and then reports case information to the CDC (59.1% and 56.8%, respectively). A large proportion of respondents incorrectly believed that the health department is able to proactively seek out contacts deemed to be "at risk" to obtain samples for pertussis testing (50.0%) and prescribe antibiotics (61.4%).

Based on their knowledge scores, respondents were classified has having either poor, fair, or good knowledge (Table 5). A score of 0-12 was considered to be poor knowledge, indicating that the physician correctly answered no more than half of all knowledge questions, while a score of 13-19 corresponded to a classification of "fair," and a score of 20 or above was considered indicative of "good" knowledge. Just over a tenth of respondents (11.1%) had good knowledge of pertussis, while nearly a third (31.1%) had poor knowledge,

further indicating that a substantial proportion of the respondents had deficits in knowledge related to several aspects of pertussis case management.

Pertussis attitude scores are presented and summarized in Table 6. On a scale ranging from 0 to 20, with a score of 0 indicating strong disagreement and 20 indicating strong agreement, the average attitude score among respondents was 14.85 with a standard deviation of 3.81, indicating that respondents generally agreed with the presented statements. Respondents were more likely to have neutral attitudes when asked whether pertussis was a high priority illness in El Paso, if reporting a case of pertussis was easy, and if reporting a case of pertussis took too much time. Respondents also generally indicated agreement with the statements that pertussis is a serious illness in young children, and that pertussis can be a serious illness in adults and adolescents.

Scores for three practices associated with diagnosis and reporting of pertussis were also determined on a four-point scale based on how often physicians reported performing serologic testing to confirm pertussis diagnosis, performing PCR or culture to confirm pertussis diagnosis, and reporting pertussis cases to the health department in a timely manner (Table 7). A score of 0 indicated that a physician never performed the particular practice, while a score of 4 indicated that the physician "almost always" performed the practice. The mean score for PCR testing was 1.68 among the 22 physicians who had encountered at least one case of pertussis, suggesting that most respondents did not regularly order PCR to confirm a suspected case of pertussis. Respondents similarly reported that they did not typically order serology to confirm pertussis diagnosis, with an average score of 1.36. When asked how often they reported cases of pertussis to the department of public health, the average score of 2.52, indicating that respondents usually, although not always, reported cases of pertussis to the EP DPH.

Bivariate Analyses

Bivariate analyses identified several physician and patient demographic characteristics that were significantly associated with knowledge, attitude, and practice scores, presented in Tables 8-11. Neither the country in which respondents received their education nor the duration of clinical practice were significantly associated with an increased knowledge score. Physicians who reported a pediatric specialty did not score significantly higher than non-pediatricians when looking at pertussis knowledge. However, physicians who had previously encountered at least one case of pertussis had a significantly higher knowledge score than physicians who had not encountered any pertussis cases (Wilcoxon, $p=0.002$, Table 8). Patient demographics, including proxy measures for socioeconomic status and mobility, were not significantly associated with respondents' knowledge scores.

When attitude scores were analyzed, pediatricians scored significantly higher than non-pediatricians (T-test, $p<0.05$, Table 8). Other physician characteristics, including country of medical training, duration of clinical practice, and number of pertussis cases encountered, were not significantly associated with attitude scores. Patient characteristics, including travel to Mexico and Medicaid payment, were not associated with a physician's attitude score.

As previously outlined, respondents were dichotomized based on how often they reported performing a variety of practices. Respondents were classified as having a PCR/culture practice score of 2.00 or less, indicating that they "never," "rarely," or "sometimes" utilized PCR or bacterial culture to confirm suspected cases of pertussis, or having a PCR practice score of 3.00 or greater, indicating that they "usually" or "always" utilized PCR to confirm suspected pertussis infection. The proportion of respondents who "usually" or "always" utilize PCR or culture was then examined across a variety of

demographic characteristics, summarized in Table 9. A significantly larger proportion of pediatricians was found to utilize PCR or culture as a confirmatory test relative to physicians practicing non-pediatric specialties (Fisher's exact, p=0.04), and similarly, a greater proportion of physicians who practiced in a hospital-based setting utilized PCR or culture relative to physicians who only practiced in outpatient settings (Fisher's exact, p=0.04). Direct experience with pertussis was also found to be marginally associated with PCR testing practices, with 47.6% (10/21) of physicians who had previously diagnosed pertussis utilizing PCR or culture, compared with just 18.6% (3/16) of physicians who had never previously diagnosed pertussis (Fisher's exact, p=0.09).

Respondents were dichotomized based on their serologic testing practices in the same manner that they were classified for PCR and bacterial culture testing practices. The proportion of respondents who indicated that they "usually" or "always" utilized serology to confirm suspected pertussis infection is summarized across various demographic characteristics in Table 10. Serologic testing practices were not found to be significantly associated with knowledge classification, country of medical training, previous experience with pertussis, or patient demographic characteristics. The difference in proportions of physicians who utilized serologic testing was found to be marginally significant across physician specialty, with 11.1% (2/18) of pediatricians utilizing serologic testing to confirm suspected pertussis infection, as compared with 39.1% (9/23) of non-pediatricians (Fisher's exact, P=0.08).

When physician reporting practices were dichotomized in a similar manner, as presented in Table 11, they were found not to differ significantly across any of the explored demographic characteristics.

Multivariate Analyses

After dichotomizing physician practices based on the frequency of performing either serologic testing or utilizing PCR and culture to confirm suspected pertussis infection as previously outlined, multivariate logistic regression was performed to examine the association between knowledge score and utilization of PCR/culture and serology, summarized in Tables 12 and 13, respectively.

As presented in Table 12, the final model for the effect of knowledge score on PCR/culture testing practices indicates that knowledge category was not significantly associated with the odds of utilizing PCR or culture to confirm suspected pertussis infection, even controlling for physician specialty (pediatric specialty vs. non-pediatric specialty), clinical work setting (hospital vs. non-hospital setting), and personal experience with pertussis (diagnosing at least one case of pertussis vs. never having diagnosed a case). Physicians with "fair" pertussis-related knowledge had odds 1.6 times greater of using PCR or culture to diagnose pertussis cases than those among physicians with "poor" knowledge ($p>0.1$). Similarly, physicians with "good" knowledge had odds 3.7 times greater than those of physicians with poor knowledge ($p>0.1$), although neither difference in odds ratio was found to be significant.

When the effect of knowledge score on serological testing practices was modeled, it was found that knowledge score was not significantly associated with the odds of performing serological testing to confirm pertussis infection controlling for clinical specialty and pertussis experience (Table 13). Physicians with "poor" knowledge had odds of ordering serologic testing to confirm pertussis infection 5.3- and 3.1-fold higher than physicians with "fair" and "good" knowledge, respectively. Neither of these differences were found to be significant.

Because knowledge classification was not significantly associated with either PCR/culture or serology testing practices, multivariate logistic regression models were constructed to identify the factors that were most strongly associated with testing behaviors to better elucidate possible targets for future interventions, as previously outlined. The final models for factors associated with utilization of PCR /culture testing and utilization of serological testing are presented in Tables 14 and 15.

As presented in Table 14, physician specialty and clinical practice setting were significantly associated with the odds of employing either PCR or culture to confirm pertussis infection. The odds for physicians with a pediatric specialty was 8.3-fold higher than that of physicians practicing non-pediatric specialties of medicine, controlling for work environment. Similarly, the odds for physicians working in a hospital setting was 7.4 times higher than that odds among physicians who exclusively worked in an outpatient setting controlling for physician specialty.

The odds of utilizing serology for diagnosis was also examined, with the final model presented in Table 15. Again, physician specialty was found to be significantly associated with the odds in question, with non-pediatricians having greater than nine-fold increase in the odds of ordering serologic testing to confirm pertussis infection relative to pediatricians ($OR=0.1$, $p<0.05$), controlling for the country of medical education. Interestingly, attending a Mexican medical school was found to be marginally significantly associated ($OR=5.6$, $p<0.1$) with higher odds of ordering serologic testing relative to physicians who had attended a U.S. medical school when controlling for physician specialty.

DISCUSSION

Knowledge, Attitudes, and Practices

Participants demonstrated relatively low levels of knowledge about several aspects of pertussis clinical management, with just over 10% of respondents answering at least 80% of questions correctly. While research regarding provider knowledge of pertussis clinical management is scarce relative to research examining provider knowledge of pertussis vaccination strategies, it appears that knowledge of pertussis reporting requirements was higher among participants than in previous studies, although knowledge regarding prevention and control measures performed by public health practitioners was similarly poor[61, 72]. Knowledge did not significantly differ by length of time spent in clinical practice, the country where participants had received medical training, specialty, or by patient characteristics. Physicians who had previously encountered and diagnosed at least one case of pertussis were more likely to have higher knowledge of pertussis clinical management than those who had never personally diagnosed a case.

Attitudes toward pertussis reporting requirements were consistent with previous findings[61], and attitudes regarding the seriousness of pertussis infection in the El Paso region were generally supportive that pertussis is a serious disease. Pediatricians were generally found to agree more strongly with statements that pertussis is a serious disease and that reporting of cases to the health department is relatively easy compared to physicians of other specialties. These attitudes may arise because a larger proportion of pediatricians had direct experience with diagnosing cases of pertussis than non-pediatricians, who were much less likely to have knowingly encountered pertussis infection in a clinical setting.

There is currently little research examining provider knowledge of pertussis testing requirements, although a 2009 study of urgent care providers in Utah showed that over 80%

of providers were able to identify PCR as the preferred method of identifying pertussis in a child, with the remainder indicating either bacterial culture or DFA[61]. In contrast, just 68% of participants indicated that PCR is an appropriate test to confirm suspected pertussis infection according to Texas state guidelines, while nearly three-quarters (73%) of respondents felt that clinical judgment alone was sufficient to confirm pertussis infection and nearly half (49%) indicated that serologic testing was appropriate. Somewhat surprisingly, physician knowledge was not significantly associated with utilizing either PCR or serology to perform confirmatory testing of suspected cases of pertussis infection.

Reporting practices were not found to differ significantly based on participant knowledge, attitudes, or across physician and patient demographic characteristics. Despite relatively uniform reporting practices across respondents, it is clear that some degree of underreporting occurs, with a quarter of respondents indicating that they rarely reported cases of suspected pertussis to the health department and half of respondents claiming to "usually" or "always" report as required.

Knowledge as a Predictor of Pertussis Testing Practices

Predictors of the odds of utilizing PCR or serology to confirm suspected cases of pertussis were of great interest, both to identify factors that may lead to an increased likelihood of correctly or incorrectly testing for an infectious disease of regional significance and to reveal potential targets for future physician-based interventions.

When multivariate logistic regression models were constructed to examine the extent to which pertussis knowledge is associated with confirmatory testing practices, it was found that on average, the odds of ordering PCR to confirm suspected pertussis infection increased 3.68-fold among physicians classified as having good pertussis-related knowledge relative to physicians with poor knowledge. It was also found that, on average, physicians with poor

knowledge had odds of utilizing serologic testing to confirm pertussis infection that were 3.14 times greater than the odds among their colleagues with good knowledge. While this relationship held after controlling for potential confounders and effect modifiers, it should be noted that the association was not deemed significant. Increasing the study sample size, either through improved participation among eligible respondents or expansion of the assessment to additional regions of the city of El Paso, may be necessary to confirm the relationship between knowledge and confirmatory testing practices.

Potential Targets for Physician-Based Intervention

Respondents had little knowledge regarding the appropriate tests to confirm pertussis infection according to Texas state guidelines, as well as poor knowledge regarding the actions taken by public health authorities when a case of pertussis has been reported. The observation that knowledge regarding pertussis clinical management was low may be attributed to the fact that the assessment study population included physicians whose clinical specialties and practice settings would make a direct encounter with pertussis infection uncommon, and who are therefore less likely to be familiar with pertussis clinical management. The experience of the El Paso Department of Public Health, however, suggests that a significant proportion of pertussis cases may be initially misdiagnosed by providers as a chronic cough or allergies, and only later confirmed as pertussis in an urgent care or emergency department setting. Thus, increasing knowledge of pertussis symptoms, appropriate laboratory testing, and state reporting requirements among physicians who are likely to unknowingly encounter and misdiagnose cases of pertussis may be an effective use of resources to reduce the risk of secondary transmission of pertussis in the Paso del Norte region.

The knowledge areas of greatest priority for future interventions among El Paso physicians should focus on the identification of symptoms that may be associated with pertussis, including the variability in clinical severity of symptoms, as well as basic epidemiologic measures of the disease in the Paso del Norte region and Texas, potential public health impacts of incorrect diagnostic testing practices, and strategies to improve reporting of both confirmed and suspected cases of pertussis.

After exploring the relationships between pertussis-related knowledge and the odds of employing PCR and serology to test suspected pertussis infection, it became clear that knowledge alone did not significantly predict either appropriate or inappropriate testing practices. Multivariate logistic regression was then used to identify other predictors of pertussis testing practices. It was found that both specialty and clinical practice setting were significantly associated with the odds of utilizing PCR to confirm pertussis infection. Pediatricians had odds eight-fold greater of utilizing PCR relative to colleagues who practiced non-pediatric specialties, controlling for clinical practice setting, while physicians who practiced medicine in a hospital setting had odds of employing PCR that were seven-fold higher than colleagues who only practiced in an outpatient or community health setting when controlling for clinical specialty. This suggests that while education is needed in all groups, targeting interventions aimed at improving the utilization of PCR to confirm suspected cases of pertussis is especially needed for physicians of non-pediatric specialties who may be less likely to suspect and diagnose pertussis infections.

Two predictors associated with use of serologic testing remained significant after backward elimination. Clinical specialty was again found to be associated with pertussis management practices, with pediatricians having reduced odds of using serologic testing inappropriately to confirm suspected pertussis infection relative to colleagues of other

specialties. Interestingly, where physicians received their medical training was found to be marginally associated with the odds of employing serologic testing. Physicians who had attended medical school in Mexico had odds of utilizing serology that were 5.6 times greater than their U.S.-trained colleagues, while physicians of other foreign medical schools also had slight, though not significant, increase in odds of using serology. Because a significant proportion of medical providers in El Paso receive medical training outside of the United States, in large part due to the geography and binational character of the region, future interventions may benefit by targeting physicians who received their medical education in other countries. Foreign countries may have differing pertussis case definitions, clinical management recommendations, vaccination coverage rates, and respiratory disease epidemiology, although ideally these factors should be minimized as graduates of foreign medical schools are required to undertake extensive clinical residency training in the United States prior to practicing medicine.

The predictors identified through backward elimination, including clinical specialty, country of medical education, and practice setting, help to identify populations that are more likely to exhibit poor clinical management of pertussis according to Texas state guidelines. These predictors, however, are not amenable to change through intervention or other means. Improving pertussis knowledge is therefore still important from the perspective of improving disease surveillance and reducing disease burden through physician-based interventions.

CONCLUSIONS & RECOMMENDATIONS

Strengths and Limitations

This assessment provides local, state, and federal public health organizations in El Paso with much-needed information about the current state of physician knowledge, attitudes, and practices regarding pertussis-related clinical management in El Paso. While the El Paso Department of Public Health has anecdotal evidence suggesting that physicians in the area continually run inappropriate diagnostic tests for pertussis, it has historically not had access to data regarding clinician knowledge of pertussis disease and diagnostic practices, knowledge of pertussis reporting guidelines in the state of Texas, case reporting practices, and attitudes regarding pertussis case reporting. This information is essential for public health practitioners in the region to better understand the factors that influence pertussis diagnostic practices and timely reporting of notifiable diseases, identify gaps in pertussis knowledge among the city's providers, and inform the creation of targeted and effective interventions designed to address shortcomings in the clinical management of a rapidly-reemerging infectious disease.

Many studies that utilize a KAP assessment describe the current state of knowledge, attitudes, and practices in a population without further exploring the relationship between knowledge and behavior. Studies that do further explore the association between knowledge and practice, however, generally do so in the context of evaluating the effectiveness of a knowledge-based intervention. Evaluation of knowledge-based interventions typically takes place using baseline and follow-up studies done before and after the specified intervention is implemented, respectively. The use of maximum likelihood logistic regression models in a piloted study, however, may help to inform efforts prior to implementation and provide insight into whether knowledge-based interventions have the potential to succeed, while also

identifying additional factors that may influence their success. This method also allows researchers to identify populations and aspects of pertussis clinical management that may benefit most from future interventions designed by state and local public health services.

While this assessment has the potential to inform intervention efforts prior to implementation, it must also be noted that the study had several important limitations, including aspects of survey design and administration, continually evolving pertussis case definitions, as well as a small sample size. There is very limited existing research regarding pertussis clinical management-related knowledge, attitudes, and practices among providers, and none that has been identified among El Paso physicians. The majority of pertussis-related KAP assessments concern provider, patient, and parent knowledge, attitudes, and practices toward the Tdap or DTaP vaccines. For this reason, the survey could not be closely modeled on previously-published, pre-tested, and piloted works. While steps were taken to ensure face validity of questions and to pilot the survey, more extensive validation was beyond the scope of this project. Knowledge may be best measured using open-ended questions so that participants are required to provide the information without encountering potentially leading questions or restrictive choices. However, due to concerns that such a survey would lead to low participation and response rates among physicians, it was decided to make the survey as simple as possible by reducing the amount of necessary write-in components and maximizing the number of questions that were multiple choice format while minimizing the number of total questions. This necessitated anticipating the most likely responses by participants for each question, as well as the compression of behavior-based questions when possible into a multiple choice format that allowed participants to select multiple answers.

The study was also limited by the methods of survey distribution and collection. Because offering incentives to complete the survey were beyond the scope and financial constraints of the project, there was much concern regarding the sampling of physicians, who generally have very low response rates to KAP surveys. In an effort to maximize respondent participation, it was elected to distribute paper copies of the survey in a marked envelope to eligible participants rather than distribute an online version of the assessment via email. Due to time and budget constraints, the survey was administered only to physicians in the central region of El Paso consisting of downtown and portions of the West Side, as defined by ZIP code. The entire city of El Paso encompasses over 250 square miles and inclusion of physicians throughout the entire area was not feasible for this project. By conducting a survey of convenience and excluding physicians in the upper West Side and the eastern portion of the city, we likely excluded many physicians who have a greater degree of experience with pertussis. A 2013 report published by the EP DPH suggests that a majority of reported pertussis cases occurred in out regions of the city, particularly in the northern and eastern portions of the city[54].

Accurate assessment of provider knowledge of pertussis clinical management, particularly knowledge of pertussis case definitions and associated clinical symptoms, is difficult to measure due to continually evolving guidelines pertaining to the classification of pertussis. At the time that the survey was conducted, the TX DSHS Guidelines for Investigation and Control of Invasive, Respiratory, Foodborne, and Vaccine-Preventable Diseases, which serves as a tool to help local and regional public health staff with surveillance activities and investigations, defined a case of pertussis as "a cough illness lasting at least 14 days AND at least one of the following additional symptoms and without other apparent case (as reported by a health professional): Paroxysmal cough, inspiratory 'whoop,'

post-tussive vomiting, sneezing and runny nose, fever, or apnea with or without cyanosis if under 1 year old." As of January 2014, however, the case definition of pertussis has been revised to exclude fever and sneezing or runny nose. In addition, there is much discussion as to whether the case definition should be further refined to include a cough illness of any duration[73], particularly among young infants, and future revision of the case definition is likely. The continual revision of pertussis case definitions underscores the importance of outreach to physicians by local, state, and federal public health organizations to ensure that clinically-relevant findings are disseminated as knowledge of infectious diseases evolves.

In addition to limitations in study design, administration, and pertussis case definitions, the assessment was also limited by a small sample size. The survey analyses included just 45 physicians, limiting the statistical power. As a result, it was likely difficult to detect true relationships between variables of interest among sub-samples in the study. Additional studies, including baseline and follow-up of any knowledge-based interventions, will need to include a larger sample to verify the relationships of interest between knowledge and behavior. This may be more easily accomplished by the EP DPH, which likely has access to greater resources and influence among physicians in the region than the CDC.

Conclusions and Recommendations

Physician knowledge of pertussis clinical management was not found to be significantly associated with pertussis testing practices as originally hypothesized. Even controlling for physician demographic characteristics, such as medical specialty, clinical practice setting, and pertussis experience, knowledge was not found to be strongly associated with testing behavior. However, knowledge may not be the best predictor of pertussis testing behavior by providers. Primary specialty, clinical practice setting, and the country of medical education were all found to be significantly associated with either PCR testing behavior or

serology testing behavior. Unfortunately, these predictors do not provide an easy opportunity for behavior change and are not characteristics that are amenable to intervention. While they are helpful for informing and targeting interventions designed by public health practitioners and researchers, knowledge will likely continue to be an important component of any physician interventions targeting the clinical management and enhanced surveillance of pertussis.

Further research will be necessary to confirm the extent of any relationship between pertussis knowledge and behavior, as well as to identify additional factors that better predict pertussis testing behavior and offer feasible opportunities for intervention. Similar assessments with a larger sample size may provide greater statistical power with which to detect a true relationship. Further studies examining the associations between specific facets of pertussis knowledge, such as knowledge of pertussis symptoms and case definitions, pertussis detection, pertussis treatment, or DTaP/Tdap vaccination, and various clinical management behaviors may also be worthwhile. The current study does not differentiate between specific aspects of pertussis knowledge beyond identifying existing gaps in knowledge. Additional opportunities may exist to examine physician board specialty certification and re-certification status, as boards are usually stringent on testing for diagnostic case definitions.

Additional qualitative research, such as focus groups or interviews, may also serve to identify existing barriers to the transition of knowledge into practice by providing an open forum for discussion that is not available in multiple choice surveys. Despite the unavailability of free response space on this survey, several surveys were returned with notes and comments expressing concerns regarding a perceived lack of support of clinicians by the EP DPH, or suggestions for how to improve communication between medical providers

and public health agencies. The local health department may find value in structuring future interventions in a manner that fosters open discussion between clinical and public health professionals to address any real or perceived lack of support among clinicians. This may also serve to improve physician participation in future surveillance, investigations, and assessments carried out by CDC, TX DSHS, or EP DPH in the region.

Until further research is done to identify factors that best predict pertussis testing behaviors, interventions in El Paso aimed at improving clinical management of pertussis should focus on improving pertussis knowledge among providers who are most likely to encounter cases of pertussis, including clinicians who may not expect to come across cases of pertussis but are likely to encounter upper respiratory infections in individuals of any age. Although improved knowledge does not appear to be significantly associated with pertussis testing practices according to this study, better knowledge among clinicians may in fact be associated with other pertussis clinical management behaviors, such as case reporting, treatment and appropriate use of prophylaxis, or pertussis vaccination. In cases where resources are limited, interventions should be targeted to groups identified as most likely to utilize pertussis confirmatory testing inappropriately, including physicians who specialize in non-pediatric medicine, practice in outpatient offices or community health centers, or who received their medical education from a Mexican medical school. Evaluation should be conducted regardless of the scope of the intervention to determine the effectiveness of the intervention and inform future research.

This study generally found physicians in El Paso to have reasonable amounts of pertussis-related knowledge, although many had significant gaps in areas such as pertussis case definitions, case reporting and subsequent action by public health workers, and diagnostic testing. Many physicians continue to utilize inappropriate diagnostic tests to

confirm pertussis infection, negatively affecting pertussis surveillance and investigation in the region. As a result, there are many existing opportunities for future research and intervention among El Paso physicians in regard to improved clinical management of pertussis. Improved clinical management will become an increasingly important priority in El Paso as pertussis incidence continues to rise in the Paso del Norte region, the state of Texas, and the United States as a whole.

REFERENCES

1. *United States-Mexico Border Health Commission Act*, in *P.L. 103-400 (22 U.S. Code, 290 n-5)*.
2. *US-México border region at a glance*. United States-México Border Health Commission.
3. *Southwest Border Unaccompanied Alien Children*. 2015 [cited 2015 February 22]; Available from: http://www.cbp.gov/newsroom/stats/southwest-border-unaccompanied-children.
4. *Health Disparities and the U.S.-México Border: Challenges and Opportunities*. 2010, United States–México Border Health Commission.
5. Soden, D.L., *At the Crossroads: U.S.-Mexico border counties in transition*. 2006, Institute for Policy and Economic Development: El Paso.
6. *USA QuickFacts from the US Census Bureau*. [cited 2014 February 13]; Available from: quickfacts.census.gov/qfd/states/00000.html.
7. United States Census Bureau, *American Community Survey, 2008*. 2008.
8. *Local Area Unemployment Statistics*, U.S.D.o. Labor, Editor.
9. United States-México Border Health Commission, *Childhood obesity and the U.S.-México border: A white paper*. 2009: El Paso.
10. *Behavioral Risk Factor Surveillance System* C.f.D.C.a. Prevention, Editor.
11. United States-México Border Health Commission, *Tuberculosis along the United States-México border: A white paper*. 2009: El Paso.
12. Institute of Medicine Forum on Microbial Threats. *The Domestic and International Impacts of the 2009-H1N1 Influenza A Pandemic: Global Challenges, Global Solutions: Workshop Summary*. 2010. Washington (DC): National Academies Press.
13. Bouri, N., et al., *Return of epidemic dengue in the United States: implications for the public health practitioner*. Public Health Rep, 2012. **127**(3): p. 259-66.
14. Notzon, F.S.A.-D., J., *Border lives: Health status in the United States-Mexico border region*. 2008, United States-México Border Health Commission: El Paso.
15. *America's uninsured crisis: Consequences for health and health care*. 2009, Institute of Medicine of the National Academies,,: Washington, DC.
16. Cooper-Patrick, L., *Patient–provider communication: the effect of race and ethnicity on process and outcomes of healthcare*, in *Unequal treatment: Confronting racial and ethnic disparities in healthcare* 2002, The National Academies Press: Washington, DC. p. 41.
17. *The Borderplex Alliance Economic Indicators*, El Paso Regional Economic Development Corporation, Editor. 2013.
18. Chamberlain, L., *2 Cities and 4 Bridges Where Commerce Flows*, in *New York Times*. 2007.
19. *Las Cruces (city) QuickFacts from the US Census Bureau*. 2014 [cited 2015 March 29]; Available from: http://quickfacts.census.gov/qfd/states/35/3539380.html.
20. *El Paso (city) QuickFacts from the US Census Bureau*. [cited 2014 February 13]; Available from: http://quickfacts.census.gov/qfd/states/48/4824000.html.
21. *El Paso (county) QuickFacts from the US Census Bureau*. [cited 2015 March 29]; Available from: http://quickfacts.census.gov/qfd/states/48/48141.html.
22. *Border Trade Vehicle Crossings*. [cited 2014 February 13]; Available from: http://texascenter.tamiu.edu/texcen_services/vehicle_crossings.asp.
23. *A Snapshot in Time: Selected Health Measures for El Paso, Tx 2011*. 2011.
24. *Health on the U.S.-Mexico border: past, present and future: a preparatory report to the future United States-Mexico Border Health Commission*. 2000: U.S. Department of Health and Human Services.

25. Warner, D.C., *Health issues at the US-Mexican border*. JAMA, 1991. **265**(2): p. 242-7.
26. Doyle, T.J. and R.T. Bryan, *Infectious disease morbidity in the US region bordering Mexico, 1990-1998*. J Infect Dis, 2000. **182**(5): p. 1503-10.
27. Centers for Disease Control and Prevention. *Winnable Battles*. 2013 [cited 2014 February 13].
28. *Pertussis Cases Continue to Rise in El Paso*. 2012, El Paso Department of Public Health.
29. Senzilet, L.D., et al., *Pertussis is a frequent cause of prolonged cough illness in adults and adolescents*. Clin Infect Dis, 2001. **32**(12): p. 1691-7.
30. Centers for Disease Control and Prevention. *Pertussis*. 2013 [cited 2014 Febraury 13].
31. Heymann, D.L., *Control of Communicable Diseases Manual*. 2008, Washington, DC: American Public Health Association.
32. *TX Invasive, Repiratory, Foodborne, and VPD Surveillance Guidelines*. 2014, Texas Department of State Health Services. p. 109-116.
33. *2013 Provisional Pertussis Surveillance Report*. 2013, Centers for Disease Control and Prevention.
34. Mink, C.M., et al., *A search for Bordetella pertussis infection in university students*. Clin Infect Dis, 1992. **14**(2): p. 464-71.
35. Deeks, S., et al., *Failure of physicians to consider the diagnosis of pertussis in children*. Clin Infect Dis, 1999. **28**(4): p. 840-6.
36. Cherry, J.D., *The epidemiology of pertussis: a comparison of the epidemiology of the disease pertussis with the epidemiology of Bordetella pertussis infection*. Pediatrics, 2005. **115**(5): p. 1422-7.
37. Cromer, B.A., et al., *Unrecognized pertussis infection in adolescents*. Am J Dis Child, 1993. **147**(5): p. 575-7.
38. Hellwig, S.M., et al., *Crucial role of antibodies to pertactin in Bordetella pertussis immunity*. J Infect Dis, 2003. **188**(5): p. 738-42.
39. de los Angeles Cortes, M., et al., *Public vaccine manufacturing capacity in the Latin American and Caribbean region: Current status and perspectives*. Biologicals, 2012. **40**(1): p. 3-14.
40. Centers for Disease Control and Prevention, *Updated recommendations for use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis (Tdap) vaccine from the Advisory Committee on Immunization Practices, 2010*. MMWR Morb Mortal Wkly Rep, 2011. **60**(1): p. 13-5.
41. Wearing, H.J. and P. Rohani, *Estimating the duration of pertussis immunity using epidemiological signatures*. PLoS Pathog, 2009. **5**(10): p. e1000647.
42. Plotkin, S.A., *Complex correlates of protection after vaccination*. Clin Infect Dis, 2013. **56**(10): p. 1458-65.
43. Elam-Evans, L.D., et al., *National, state, and selected local area vaccination coverage among children aged 19-35 months - United States, 2013*. MMWR Morb Mortal Wkly Rep, 2014. **63**(34): p. 741-8.
44. Centers for Disease, C. and Prevention, *National, state, and urban area vaccination coverage among children aged 19-35 months--United States, 2003*. MMWR Morb Mortal Wkly Rep, 2004. **53**(29): p. 658-61.
45. *Mexico: WHO and UNICEF estimates of immunization coverage: 2013 revision*. 2014, UNICEF.
46. McCormick, C.M. and J.S. Czachor, *Pertussis infections and vaccinations in Bolivia, Brazil and Mexico from 1980 to 2009*. Travel Med Infect Dis, 2013. **11**(3): p. 146-51.
47. Clark, T.A., *Changing pertussis epidemiology: everything old is new again*. J Infect Dis, 2014. **209**(7): p. 978-81.

48. Skoff, T.H., et al., *Early Impact of the US Tdap vaccination program on pertussis trends.* Arch Pediatr Adolesc Med, 2012. **166**(4): p. 344-9.
49. Centers for Disease, C. and Prevention, *National and state vaccination coverage among adolescents aged 13-17 years--United States, 2011.* MMWR Morb Mortal Wkly Rep, 2012. **61**(34): p. 671-7.
50. Elam-Evans, L.D., et al., *National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13-17 Years - United States, 2013.* Mmwr-Morbidity and Mortality Weekly Report, 2014. **63**(29): p. 625-633.
51. Winter, K., et al., *California pertussis epidemic, 2010.* J Pediatr, 2012. **161**(6): p. 1091-6.
52. Centers for Disease Control and Prevention (U.S.), *Pertussis Epidemic — Washington, 2012.* MMWR Morb Mortal Wkly Rep 2012. **61**(28): p. 517-522.
53. Texas Department of State Health Services (TX DSHS). *Pertussis Data.* 2014 June 13 [cited 2014 June 13]; Available from: http://www.dshs.state.tx.us/idcu/disease/pertussis/statistics/.
54. City of El Paso Department of Public Health, *2013 Pertussis Report.* 2014: El Paso. p. 10.
55. Ochoa-Perez, U.R., et al., *Epidemiology of Bordetella pertussis in San Luis Potosi, Mexico.* Pediatr Infect Dis J, 2014. **33**(5): p. 540-2.
56. Lievano, F.A., et al., *Issues associated with and recommendations for using PCR to detect outbreaks of pertussis.* J Clin Microbiol, 2002. **40**(8): p. 2801-5.
57. Tozzi, A.E., et al., *Diagnosis and management of pertussis.* CMAJ, 2005. **172**(4): p. 509-15.
58. Bureau of Communicable Disease Control, *Guide to Surveillance, Reporting, and Control: Pertussis*. 2006, Massachusetts Department of Public Health. p. 38.
59. Halperin, S.A., R. Bortolussi, and A.J. Wort, *Evaluation of culture, immunofluorescence, and serology for the diagnosis of pertussis.* J Clin Microbiol, 1989. **27**(4): p. 752-7.
60. World Health Organization, *Advocacy, communication and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys*. 2008, Geneva: World Health Organization. 68.
61. Staes, C.J., et al., *Urgent care providers' knowledge and attitude about public health reporting and pertussis control measures: implications for informatics.* J Public Health Manag Pract, 2009. **15**(6): p. 471-8.
62. Zimmerman, R.K., et al., *Barriers to measles and pertussis immunization: the knowledge and attitudes of Pennsylvania primary care physicians.* Am J Prev Med, 1997. **13**(2): p. 89-97.
63. Hoffait, M., et al., *Pertussis knowledge, attitude and practices among European health care professionals in charge of adult vaccination.* Hum Vaccin, 2011. **7**(2): p. 197-201.
64. Alden, D.L., J. Friend, and M.B. Chun, *Shared Decision Making and Patient Decision Aids: Knowledge, Attitudes, and Practices Among Hawai 'i Physicians.* Hawai'i Journal of Medicine & Public Health, 2013. **72**(11): p. 396.
65. Betz, M.E., et al., *Knowledge, attitudes, and practices of emergency department providers in the care of suicidal patients.* Depress Anxiety, 2013. **30**(10): p. 1005-12.
66. de Miranda Gonçalves, I.C. and M.J.F. Gonçalves, *Knowledge, attitudes and practices of nurses and doctors about the vertical transmission of hepatitis B1.* Rev. Latino-Am. Enfermagem, 2013. **21**(5): p. 1030-8.
67. James, L., et al., *Emergency care physicians' knowledge, attitudes, and practices related to surveillance for foodborne disease in the United States.* Clin Infect Dis, 2008. **46**(8): p. 1264-70.
68. Sinkowitz-Cochran, R.L., et al., *The associations between organizational culture and knowledge, attitudes, and practices in a multicenter Veterans Affairs quality improvement initiative*

to prevent methicillin-resistant Staphylococcus aureus. Am J Infect Control, 2012. **40**(2): p. 138-43.

69. Zhou, J.J., et al., *Clinicians' Knowledge, Attitudes, and Practices regarding Infections with Multidrug-Resistant Gram-Negative Bacilli in Intensive Care Units.* Infection Control and Hospital Epidemiology, 2013. **34**(3): p. 274-283.
70. Ho, T.S., et al., *Knowledge, attitude, and practice of dengue disease among healthcare professionals in southern Taiwan.* J Formos Med Assoc, 2013. **112**(1): p. 18-23.
71. Lorenz, A.N., *Assessment of Pesticide Knowledge, Attitudes, and Practices Among Pregnant Women in Northern Thailand*, in *Environmental Health*. 2011, Emory University: Rollins School of Public Health. p. 134.
72. Tuttle, J.T., E. , *Knowledge, Attitudes, and Practices (KAP) Among Georgia Pediatricians*, in *1st National Immunization Conference Online*. 2012.
73. DeBolt, C., *Revision of the pertussis surveillance case definition to more accurately capture the burden of disease among infants <1 year of age* 2013, Council of State and Territorial Epidemiologists. p. 10.

TABLES & FIGURES

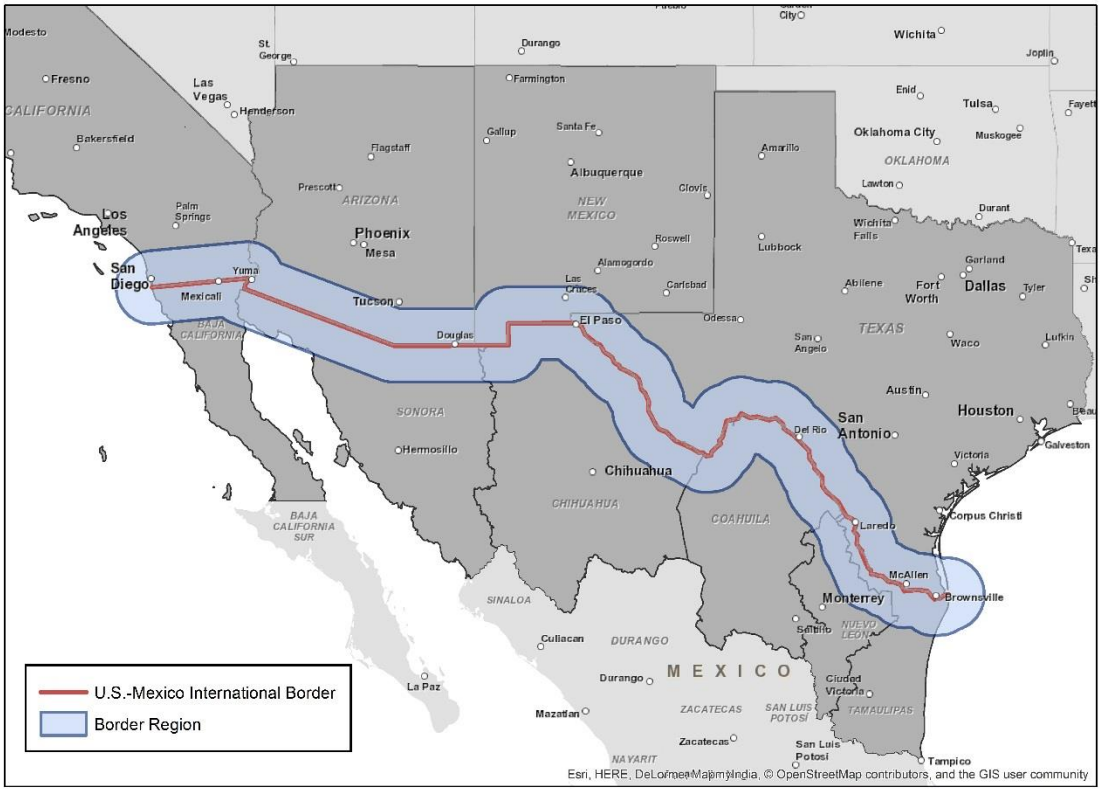


Figure 1. The United States-Mexico border region, as defined by the United States-Mexico Border Health Commission Act.

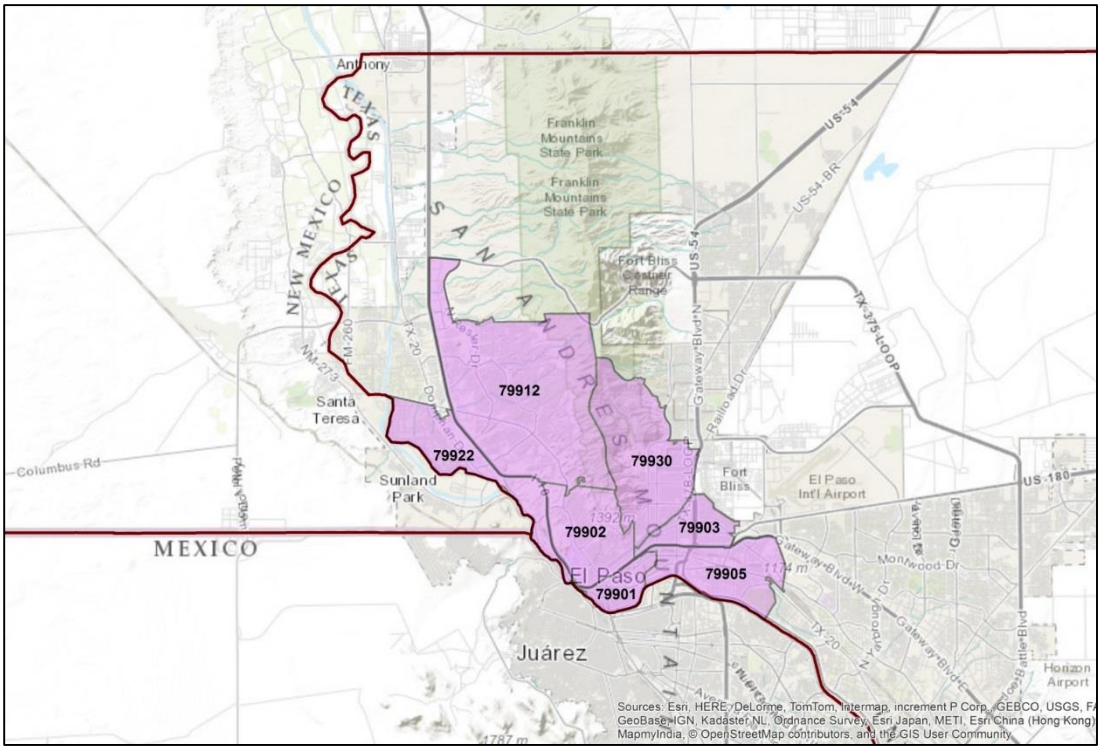


Figure 2. Central El Paso, defined as ZIP codes 79901, 79902, 79903, 79905, 79912, 79922, and 79930, was the region where the KAP survey was distributed.

Table 1. Self-reported demographic characteristics of participating physicians and demographic characteristics of patients as estimated by respondents

Physician Demographics	N	(%)
Practice Setting*	**45**	
Outpatient Setting	41	(91.1)
Inpatient/Hospital Setting	20	(44.4)
Emergency Department/Urgent Care	5	(11.1)
Intensive Care Unit	10	(22.2)
Community Health Center	3	(6.7)
Duration of Clinical Practice	**43**	
0-5 years	11	(25.6)
6-10 years	7	(16.3)
11-15 years	5	(11.6)
16+ years	20	(46.5)
Primary Specialty	**45**	
General Practice	2	(4.4)
Family Medicine	6	(13.3)
Internal Medicine	6	(13.3)
Pediatrics	19	(42.2)
Obstetrics/Gynecology	2	(4.4)
Allergy/Immunology	1	(2.2)
Other	9	(20.0)
Country of Medical Education	**45**	
United States	23	(51.1)
Mexico	13	(28.9)
Other	9	(20.0)
Patient Demographics	**N**	**(%)**
% Patients using Medicaid/Self-Payment	**44**	
0-10%	6	(13.6)
11-20%	3	(6.8)
21-30%	10	(22.7)
31%+	20	(44.5)
Don't Know	5	(11.4)
% Patients regularly traveling to Mexico	**44**	
0-10%	10	(22.7)
11-20%	11	(25.0)
21-30%	5	(11.4)
31%+	14	(31.8)
Don't Know	4	(9.1)
Primary Age of Patients	**44**	
Young Children (under 2 years)	11	(25.0)
Children and adolescents (2-19 years)	10	(22.7)
Adults (20-64 years)	19	(43.2)
Seniors (65+ years)	4	(9.1)

* Respondents could select multiple answers

Table 2. Physician experience with pertussis indicated by the total number of cases diagnosed over respondents' careers and the perceived five-year change in annual incidence of pertussis

Pertussis Experience	N	(%)
Number of Diagnosed Pertussis Cases	**44**	
None	22	(50.0)
1-5	17	(38.6)
6+	5	(11.4)
Perceived Change in Annual Incidence Over Past 5 Years		
Physicians Who Have Previously Diagnosed Pertussis	**18**	
Increase	8	(40.0)
Decrease	4	(20.0)
No change	3	(15.0)
Don't Know	5	(25.0)
Physicians Who Have Never Diagnosed Pertussis	**6**	
Increase	1	(16.7)
No change	1	(16.7)
Don't Know	4	(66.7)

Table 3. Differences in the proportion of physicians who have encountered pertussis by medical specialty, duration of clinical practice excluding residency training, and country of medical training

	Number of respondents	Physicians who have encountered pertussis	
Demographic Characteristic	**N**	**N**	**(%)**
Physician Specialty	**44**		
Pediatrics	19	13	(68.4)
Other	25	9	(36.0)
P-value		**0.03**	
Clinical Practice Duration	**42**		
0-5 years	11	2	(18.2)
6-10 years	7	4	(57.1)
11-15 years	5	2	(40.0)
16+ years	19	13	(68.4)
P-value		**0.05**	
Country of Medical Education	**44**		
United States	22	8	(36.4)
Mexico	13	11	(84.6)
Other	9	3	(33.3)
P-Value		**0.01**	

Table 4. Distribution of correct responses to pertussis knowledge questions and knowledge score summary among all respondents

Pertussis knowledge questions and possible answers	N	Correct Response	% Correct
What is the minimum cough duration associated with pertussis? (N=36)			
7 days	11		
10 days	5	14 days	22.2%
14 days	8		
21 days	12		
Is immunity following pertussis vaccination lifelong? (N=39)			
Yes	0	No	92.3%
No	36		
Don't Know	3		
Is immunity following pertussis infection lifelong? (N=38)			
Yes	1	No	76.3%
No	29		
Don't Know	8		
Which of the following statements is correct regarding reporting of pertussis to public health in Texas? (N=38)			
Pertussis is not a notifiable disease in Texas	1	All suspected and confirmed cases should be reported in 24 hours	84.2%
Pertussis reporting should occur with laboratory confirmed cases only	5		
All suspected and confirmed cases should be reported within 24 hours	32		
Pertussis should be reported only if it is present in infants less than 1 year of age	0		
Other than cough duration, which of the following symptoms may be associated with pertussis?* (N=39)			
Paroxysms of coughing	35	Yes	89.7%
Sneezing and runny nose	22	Yes	56.4%
Inspiratory "whoop"	35	Yes	89.7%
Vomiting	31	Yes	79.5%
Apnea	24	Yes	61.5%
Fever	26	Yes	66.7%

Table 4. (cont.) Distribution of responses to pertussis knowledge questions and knowledge score summary among all respondents

Pertussis knowledge questions and possible answers	N	Correct Response	% Correct
Which of the following scenarios are sufficient to confirm diagnosis of pertussis?* (N=36)			
Cough illness of two weeks with paroxysms of coughing, inspiratory whoop, post-tussive vomiting, or apnea	13	No	36.1%
Acute cough of any duration with isolation of *B. pertussis* from a clinical specimen	25	Yes	69.4%
A case that meets the clinical case definition with *B. pertussis*-specific nucleic acid detected by PCR	23	Yes	63.9%
A case that meets the clinical case definition with *B. pertussis* antibodies detected serologically	20	No	55.6%
A case that meets the clinical case definition and is epidemiologically linked to a laboratory-confirmed case	18	Yes	50.0%
Which of the following methods are confirmatory for the purposes of public health reporting of pertussis?* (N=41)			
Clinical judgment alone is sufficient	30	No	73.2%
Culture	25	Yes	61.0%
PCR	28	Yes	68.3%
Serology	21	No	51.2%
Direct Fluorescent Antibody (DFA)	26	No	63.4%
When a case of pertussis is reported the health department may take which of the following actions?* (N=44)			
Tally the case for statistical purposes	26	Yes	59.1%
Call the patient or family to identify contacts at risk of getting the disease	34	Yes	77.3%
Prescribe antibiotics for contacts	27	No	61.4%
Go to the patient's house and obtain samples from an untested patient or asymptomatic contact	22	No	50.0%
Report the case electronically to the CDC	25	Yes	56.8%
	Knowledge Score Summary†		
Mean (SD)		**14.64**	**(4.51)**
Median (Q3, Q1)		**15.00**	**(18.00, 12.00)**

* Respondents could select multiple answers

† Knowledge scores range from 0-25

Table 5. Classification of physician knowledge by knowledge score

Physician Knowledge Classification	N	(%)
Knowledge Classification	**45**	
Poor (Score 0-12)	14	(31.1%)
Fair (Score 13-19)	26	(57.8%)
Good (Score 20-15)	5	(11.1%)

Table 6. Summary of pertussis attitude scores for all respondents

		Score	
Physician attitudes toward pertussis	**N**	**Mean (SD)**	**Median (Q3,Q1)**
Attitudes on the importance of pertussis*			
Pertussis is a high priority illness in El Paso	40	2.85 (0.98)	3.0 (3.0,2.5)
Attitudes on the severity of pertussis illness*			
Pertussis is a serious illness in young children	40	3.48 (0.78)	4.0 (4.0,3.0)
Pertussis can be a serious illness in adolescents and adults	40	3.15 (0.83)	3.0 (4.0,3.0)
Attitudes on pertussis reporting*			
Reporting a case of pertussis to the health department is easy	40	2.83 (0.90)	3.0 (3.5,2.0)
Reporting a case of pertussis to the health department takes too much time	40	2.55 (0.96)	2.0 (3.0,2.0)
Attitudes Score Summary†	**40**	**14.85 (3.21)**	**15.0 (17.0,13.0)**

***** Individual attitude scores range from 0 to 4 based on whether respondents strongly disagreed, disagreed, were neutral toward, agreed, or strongly agreed with each statement

† Aggregate attitude scores ranges from 0 to 20 reflecting the sum of each individual attitude score

Table 7. Summary of pertussis testing and reporting practice scores for all respondents

Physician practices regarding pertussis testing and reporting	N	Score	
		Mean (SD)	Median (Q3,Q1)
Testing*			
Confirms suspected pertussis using PCR or culture in lieu of serologic testing	37	1.68 (1.42)	2.00 (3.0,0.0)
Confirms suspected pertussis using serologic testing in lieu of PCR or culture	41	1.36 (1.41)	1.00 (3.0,0.0)
Reporting*			
Reports suspected or confirmed cases of pertussis to the local health department	41	2.53 (1.32)	3.00 (4.0,1.0)

* Practice scores range from 0-4 based on whether respondents never, rarely, sometimes, usually, or always performed a given action

Table 8. Mean physician knowledge and attitude scores of participants by select demographic characteristics

	Score (Mean ± SD)	
Demographic Characteristics	**Knowledge**	**Attitudes**
Country of Medical Education		
United States	13.56 ± 5.30	15.11 ± 2.87
Mexico	15.77 ± 3.70	15.31 ± 2.39
Other	15.78 ± 2.68	13.67 ± 4.69
P-value	0.35	0.46
Clinical Practice Duration		
0-5 years	14.90 ± 4.93	14.33 ± 5.50
6-10 years	12.14 ± 3.48	15.00 ± 2.28
11-15 years	13.60 ± 3.21	14.40 ± 2.51
16+ years	15.20 ± 4.83	15.11 ± 2.45
P-value	0.37	0.94
Primary Specialty		
Pediatrics	15.84 ± 4.36	16.12 ± 2.26
Other	13.77 ± 4.49	13.91 ± 3.51
P-value	0.11	**0.03**
Clinical Practice Setting		
Hospital and Outpatient	14.64 ± 4.09	15.06 ± 2.49
Outpatient only	14.65 ± 5.09	14.71 ± 3.65
P-value	0.98	0.74
Diagnosed Pertussis Cases		
None	12.86 ± 4.49	14.63 ± 3.80
1+ cases	16.77 ± 3.39	15.44 ± 2.73
P-value	**0.002**	0.57
% Patients using Medicaid/Self-Payment		
0-10%	12.83 ± 4.96	14.40 ± 3.05
10% +	15.33 ± 4.11	15.30 ± 2.42
P-value	0.22	0.46
% Patients regularly traveling to Mexico		
0-10%	14.10 ± 3.45	14.67 ± 2.24
10% +	15.37 ± 4.15	15.30 ± 2.58
P-value	0.37	0.52

Table 9. Proportion of respondents who indicated "usually" or "always" utilizing PCR or bacterial culture to confirm suspected pertussis infection

	"usually" or "always" order PCR or culture		
Physician Characteristics	**N**	**(%)**	**p-value**
Knowledge	**37**		
Poor	1	(14.3)	
Fair	10	(40.0)	0.58
Good	2	(40.0)	
Country of Medical Education	**37**		
United States	5	(31.3)	
Mexico	5	(38.5)	0.91
Other	3	(37.5)	
Clinical Practice Duration	**35**		
0-5 years	2	(28.6)	
6-10 years	1	(20.0)	0.69
11-15 years	3	(60.0)	
16+ years	7	(38.9)	
Primary Specialty	**37**		
Pediatrics	9	(56.3)	**0.04**
Non-pediatrics	4	(19.1)	
Clinical Practice Setting	**37**		
Hospital and Outpatient	9	(56.3)	**0.04**
Outpatient only	4	(19.1)	
Diagnosed Pertussis Cases	**37**		
None	3	(18.6)	**0.09**
1+ cases	10	(47.6)	
% Patients using Medicaid/Self-Payment	**33**		
0-10%	0	(0.0)	0.13
10% +	12	(42.9)	
% Patients regularly traveling to Mexico	**34**		
0-10%	2	(22.2)	0.44
10% +	10	(40.0)	

Table 10. Proportion of respondents who indicated "usually" or "always" utilizing serologic testing to confirm suspected pertussis infection

	"usually" or "always" order serology		
Physician Characteristics	**N**	**(%)**	**p-value**
Knowledge	**41**		
Poor	5	(41.7)	
Fair	4	(16.7)	0.16
Good	2	(40.0)	
Country of Medical Education	**41**		
United States	4	(19.1)	
Mexico	5	(38.5)	0.46
Other	2	(28.6)	
Clinical Practice Duration	**39**		
0-5 years	3	(33.3)	
6-10 years	3	(42.9)	0.46
11-15 years	0	(0.0)	
16+ years	4	(21.1)	
Primary Specialty	**41**		
Pediatrics	2	(11.1)	**0.08**
Non-pediatrics	9	(39.1)	
Clinical Practice Setting	**41**		
Hospital and Outpatient	5	(27.8)	0.90
Outpatient only	6	(26.1)	
Diagnosed Pertussis Cases	**40**		
None	5	(27.8)	0.97
1+ cases	6	(27.3)	
% Patients using Medicaid/Self-Payment	**37**		
0-10%	1	(16.7)	1.00
10% +	7	(22.6)	
% Patients regularly traveling to Mexico	**38**		
0-10%	3	(30.0)	0.67
10% +	6	(21.4)	

Table 11. Proportion of respondents who indicated "usually" or "always" reporting a case of pertussis to the local health department

	"usually" or "always" report a case of pertussis		
Physician Characteristics	**N**	**(%)**	**p-value**
Knowledge	**41**		
Poor	7	(63.6)	
Fair	14	(53.8)	0.71
Good	3	(75.0)	
Country of Medical Education	**41**		
United States	12	(63.2)	
Mexico	8	(61.5)	0.62
Other	4	(44.4)	
Clinical Practice Duration	**39**		
0-5 years	5	(55.6)	
6-10 years	5	(71.4)	0.61
11-15 years	4	(80.0)	
16+ years	3	(50.0)	
Primary Specialty	**41**		
Pediatrics	12	(66.7)	0.35
Non-pediatrics	12	(52.2)	
Clinical Practice Setting	**41**		
Hospital and Outpatient	10	(55.6)	0.73
Outpatient only	14	(60.9)	
Diagnosed Pertussis Cases	**40**		
None	10	(92.6)	0.37
1+ cases	14	(66.7)	
% Patients using Medicaid/Self-Payment	**36**		
0-10%	2	(33.3)	0.16
10% +	21	(70.0)	
% Patients regularly traveling to Mexico	**37**		
0-10%	7	(77.8)	0.43
10% +	16	(57.1)	

Table 12. Final model for the association between knowledge and utilizing PCR or culture testing to confirm pertussis diagnosis

Predictor	Referent Group	Odds Ratio	Confidence Interval	Width of Confidence Interval	Parameter Estimate	Standard Error	p-value
Intercept	N/A	N/A	N/A	N/A	-3.42	1.35	**0.01**
Knowledge- Fair	Knowledge-Poor	1.618	(0.114, 23.022)	22.908	0.48	1.35	0.72
Knowledge- Good	Knowledge-Poor	3.681	(0.140, 96.478)	96.338	1.30	1.67	0.43
Pediatric Specialty	Other Specialty	7.920	(1.043, 60.120)	59.077	2.07	1.03	**0.05**
Hospital + Outpatient Setting	Outpatient Only	8.220	(1.302, 51.896)	50.549	2.11	0.94	**0.03**
Diagnosed Pertussis	Never Diagnosed Pertussis	1.429	(0.201, 10.147)	9.946	0.36	1.00	0.72

Table 13. Final model for the association between knowledge and utilizing serologic testing to confirm pertussis diagnosis

Predictor	Referent Group	Odds Ratio	Confidence Interval	Width of Confidence Interval	Parameter Estimate	Standard Error	p-value
Intercept	N/A	N/A	N/A	N/A	0.03	0.68	0.96
Knowledge- Fair	Knowledge-Poor	0.187	(0.025, 1.416)	1.391	-1.67	1.03	0.10
Knowledge- Good	Knowledge-Poor	0.318	(0.022, 4.567)	4.545	-1.14	1.36	0.40
Pediatric Specialty	Other Specialty	0.164	(0.024, 1.104)	1.080	-1.80	0.97	**0.06**
Diagnosed Pertussis	Never Diagnosed Pertussis	3.458	(0.461, 25.938)	25.477	1.24	1.03	0.23

Table 14. Final model for other predictors of utilizing PCR or culture testing to confirm pertussis diagnosis

Predictor	Referent Group	Odds Ratio	Confidence Interval	Width of Confidence Interval	Parameter Estimate	Standard Error	p-value
Intercept	N/A	N/A	N/A	N/A	-2.69	0.90	**0.003**
Pediatric Specialty	Other Specialty	8.285	(1.399, 49.066)	47.667	2.11	0.91	**0.02**
Hospital + Outpatient Setting	Outpatient Only	7.424	(1.205, 45.761)	44.556	2.00	0.93	**0.03**

Table 15. Final model for other predictors of utilizing serologic testing to confirm pertussis diagnosis

Predictor	Referent Group	Odds Ratio	Confidence Interval	Width of Confidence Interval	Parameter Estimate	Standard Error	p-value
Intercept	N/A	N/A	N/A	N/A	-0.93	0.59	0.12
Pediatrics	Other Specialty	0.108	(0.015, 0.798)	0.783	-2.22	1.02	**0.03**
Medical School- Mexico	Medical School- U.S.	5.646	(0.824, 38.713)	37.889	1.73	0.98	**0.08**
Medical School-Foreign	Medical School- U.S	1.527	(0.193, 12.112)	11.919	0.42	1.06	0.69

APPENDICES

Appendix 1: Assessment Tool

Assessment of Knowledge, Attitudes, and Practices Regarding Pertussis in El Paso Physicians

The purpose of this study is to assess the knowledge, attitudes, and practices of El Paso physicians regarding the diagnosis and reporting of cases of pertussis. The study is sponsored by the El Paso Department of Public Health and the CDC El Paso Quarantine Station. The survey is 30 questions long and should take 15 minutes or less to complete. Results from this assessment will be used to tailor pertussis education for El Paso physicians. Your participation is completely voluntary and confidential. We will not collect your name and other facts that might point to you as part of this study. All participation will take place anonymously and investigators will be blind to the identity of study participants.

1. **Do you currently diagnose and treat patients and plan to continue to do so for the next 12 months?**
   - ☐No, I do not. ***You may stop here, thank you for your participation***
   - ☐Yes, I currently see patients. ***Please continue with the survey.***

2. **Where do you see patients? (Check all that apply)**
   - ☐Outpatient clinic or office
   - ☐Community Health Center
   - ☐Intensive care unit
   - ☐Emergency Department/Urgent care
   - ☐Inpatient hospital ward

3. **How many years have you been in clinical practice?**
   - ☐5 years or less
   - ☐6-10 years
   - ☐11-15 years
   - ☐16 or more years

4. **What is your primary specialty?**
   - ☐General Practice
   - ☐Family Medicine
   - ☐Internal Medicine
   - ☐Pediatrics
   - ☐Obstetrics/Gynecology
   - ☐Allergy/Immunology
   - ☐Other (please specify): _____

5. **In what country did you attend medical school?**
   - ☐United States
   - ☐Mexico
   - ☐Other (please specify): _____

6. **What percentage of your patient volume self-pays or utilizes Medicaid?** ***(You do NOT need to use an outside source for more accurate information-just give your best estimate)***
   - ☐0-10%
   - ☐11-20%
   - ☐21-30%
   - ☐More than 30%
   - ☐I don't know

7. **What percentage of your patients are persons that reside in or travel regularly to Mexico?** ***(You do NOT need to use an outside source for more accurate information-just give your best estimate)***
   - ☐0-10%
   - ☐11-20%
   - ☐21-30%
   - ☐More than 30%
   - ☐I don't know

8. **How would you categorize the age of the majority of your patients?**
   - ☐Young children (Under 2 years)
   - ☐Children and adolescents (2-19 years)
   - ☐I don't know
   - ☐Adults (20-64 years)
   - ☐Seniors (65+)

9. **How many cases of pertussis have you diagnosed in the past five years?**
   - ☐None
   - ☐1-5
   - ☐6-10
   - ☐11-15
   - ☐16-20
   - ☐21+

10. How has the annual number of pertussis cases that you've encountered changed over the last five years?

☐The number has increased ☐The number not changed ☐I don't know if the number has changed
☐The number has decreased ☐I haven't encountered any cases of pertussis in the last five years

11. What is the minimum cough duration associated with clinical pertussis?

☐7 days ☐10 days ☐14 days ☐21 days or greater

12. Other than cough duration, which of the following symptoms may be associated with pertussis? (Check all that apply)

☐Paroxysms of coughing ☐Sneezing and runny nose ☐Inspiratory "whoop"
☐Vomiting ☐Apnea ☐Fever

13. Is immunity following pertussis vaccination lifelong?

☐Yes ☐No ☐I don't know

14. Is immunity following pertussis infection lifelong?

☐Yes ☐No ☐I don't know

15. In an adolescent or adult patient presenting with nonspecific symptoms, do you exclude pertussis from a differential diagnosis for any of the following reasons? (Check all that apply)

☐The patient is up to date with DTaP or Tdap vaccinations
☐Pertussis is largely a childhood disease
☐The clinical findings are not consistent with pertussis
☐Pertussis is an uncommon infection in El Paso
☐I do not rule out pertussis as a possible diagnosis without other apparent cause

16. Which of the following are sufficient to confirm diagnosis of pertussis? (Check all that apply)

☐Cough illness of 2 weeks duration with paroxysms of coughing, inspiratory whoop, post-tussive vomiting, or apnea
☐Acute cough of any duration with isolation of *B. pertussis* from a clinical specimen
☐A case that meets the clinical case definition with *B. pertussis*-specific nucleic acid detected by PCR
☐A case that meets the clinical case definition with *B. pertussis* antibodies detected serologically
☐A case that meets the clinical case definition and is epidemiologically linked to a laboratory-confirmed case

17. Which of the following statements is correct regarding reporting of pertussis to public health in Texas?

☐Pertussis is not a notifiable disease in Texas
☐Pertussis reporting should occur with laboratory confirmed cases only
☐All suspected and confirmed cases should be reported within 24 hours
☐Pertussis should be reported only if it is present in infants less than 1 year of age

18. How often do you utilize PCR or culture to confirm clinical suspicion of pertussis in lieu of serology?

☐Always ☐Usually ☐Sometimes ☐Rarely ☐Never

19. How often do you utilize serologic testing to confirm clinical suspicion of pertussis in lieu of PCR or culture?

☐Always ☐Usually ☐Sometimes ☐Rarely ☐Never **(Skip to Question 21)**

20. For which of the following reasons have you ordered serologic testing rather than other laboratory methods when confronted with a suspected case of pertussis? (Check all that apply)

☐Collecting a nasopharyngeal swab is difficult
☐Collecting a nasopharyngeal swab takes too much time
☐I am not comfortable collecting a nasopharyngeal swab
☐Patients are more likely to accept phlebotomy than a nasopharyngeal swab
☐It is easier to perform phlebotomy than collect a nasopharyngeal swab
☐The patient presented late in the course of illness, when other methods such as culture or PCR were less likely to yield accurate results
☐Serologic testing is less expensive than other laboratory methods
☐Other (please specify): _____

21. Which of the following methods are confirmatory for the purposes of public health reporting of pertussis? (Check all that apply)

☐Clinical judgment alone is sufficient ☐Culture ☐PCR
☐Serology ☐Direct Fluorescent Antibody (DFA) ☐I don't know

22. How often does your practice report cases of pertussis to the health department?

☐Always ☐Usually ☐Sometimes ☐Rarely

23. Who in your practice contacts the health department to report cases of reportable disease? (Check all that apply)

☐Providers ☐Laboratory personnel ☐Medical Assistants ☐Office Assistants
☐Infection control nurses ☐Nurses ☐Somebody does, but I'm not sure who
☐Other (please specify): _____

24. After a case of pertussis is reported to the health department, the health department may take which of the following actions? (Check all that apply)

☐Tally the case for statistical purposes
☐Call the patient or family to identify contacts at risk of getting the disease
☐Prescribe antibiotics for contacts
☐Go to the patient's house and obtain a sample from an untested patient or asymptomatic contact
☐Report the case electronically to the CDC
☐I don't know

25. When you encounter a clinical case that you suspect to be pertussis, what action do you take? (Check all that apply)

☐Supply supportive care ☐Prescribe antibiotics
☐Identify and prescribe antibiotics to close contacts ☐Administer a booster of DTaP or Tdap to close contacts
☐I don't encounter suspected cases of pertussis ☐Other (please specify): _____

For Questions 26-30, rate how strongly you agree or disagree with the following statements

26. Pertussis is a high priority illness in El Paso

☐Strongly Disagree ☐Disagree ☐Neutral ☐Agree ☐Strongly Agree

27. Pertussis is a serious illness in young children

☐Strongly Disagree ☐Disagree ☐Neutral ☐Agree ☐Strongly Agree

28. Pertussis can be a serious illness in adolescents and adults

☐Strongly Disagree ☐Disagree ☐Neutral ☐Agree ☐Strongly Agree

29. Reporting a case of pertussis to the health department is easy

☐Strongly Disagree ☐Disagree ☐Neutral ☐Agree ☐Strongly Agree

30. Reporting a case of pertussis to the health department takes too much time

☐Strongly Disagree ☐Disagree ☐Neutral ☐Agree ☐Strongly Agree

Appendix 2: Informed Consent Document

Assessment of El Paso Physician Knowledge, Attitudes, and Practices Regarding Pertussis Information Sheet for Office Managers

Introduction

You are being asked to assist in the distribution of a community health assessment sponsored by the El Paso Department of Public Health and the Centers for Disease Control and Prevention El Paso Quarantine Station. This page is designed to give you all the information you need to know about the assessment.

You may keep a copy of this information sheet.

Study Overview

Pertussis is a highly contagious and potentially serious disease, especially in young children who have not been completely vaccinated. From 2012 to 2013 the El Paso Department of Public Health reported an increase in cases of 33%. Thirty one cases have been reported through May 2014, compared to 35 for the same period in 2013. Because of the high morbidity and mortality associated with pertussis in infants, it is important that El Paso Public Health agencies better understand factors that may be associated with the rising number of cases.

The purpose of this study is to assess the knowledge, attitudes, and practices of El Paso physicians regarding the diagnosis and reporting of pertussis cases. From this study, we hope to better characterize the existing knowledge of pertussis in the El Paso medical community and provide public health officials with information that may be utilized in future interventions that address the increasing number of pertussis cases in El Paso.

Procedures

We are asking physicians from different specialties to complete an anonymous, one-time questionnaire consisting of 30 questions. The time required to complete the questionnaire should be no more than 15 minutes. Participation will be completely anonymous and confidential; study staff will not know which physicians have participated.

We ask that you distribute the included survey to physicians in your practice and gather the completed surveys so that they may be collected by study staff.

Compensation

Participants will not be offered payment or compensation for being part of this study.

Confidentiality

We will not collect participants' name or other facts that might point to them as part of this study. All participation will take place anonymously and investigators will be blind to the identity of study participants.

Voluntary Participation and Withdrawal from the Study

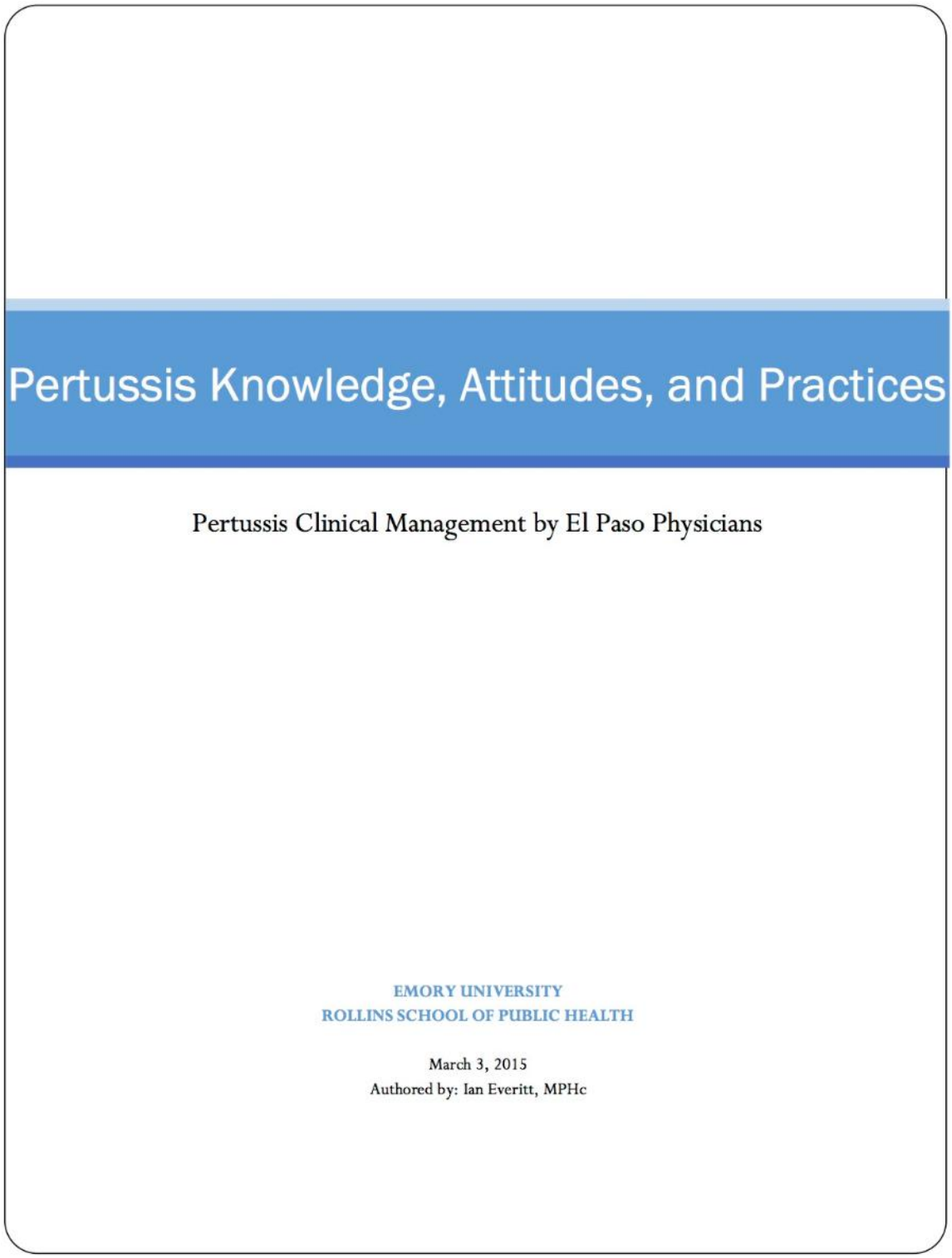
Participation is completely voluntary. Participants may refuse to answer any questions that they do not wish to answer.

Contact Information

Contact the El Paso Quarantine Station at 915-834-5950 or Ian Everitt at ygn5@cdc.gov:

- if you have any questions about this study or your part in it, or
- if you have questions, concerns, or complaints about the assessment

Appendix 3: Report of Findings



Pertussis Knowledge, Attitudes, and Practices

Pertussis Clinical Management by El Paso Physicians

EMORY UNIVERSITY
ROLLINS SCHOOL OF PUBLIC HEALTH

March 3, 2015

Authored by: Ian Everitt, MPHc

Pertussis Knowledge, Attitudes, and Practices

Pertussis Clinical Management by El Paso Physicians

Table of Contents

EXECUTIVE SUMMARY

Current pertussis surveillance methods utilized by public health officials rely heavily on prompt and accurate case reporting by physicians to accurately characterize trends in pertussis incidence and to implement meaningful disease control and response policies. However, cases of pertussis in El Paso are believed to be heavily underreported, in part due to existing barriers to health care access, as well as due to failure by physicians to consider pertussis in the differential diagnosis of patients with cough. Despite this suspected underreporting of pertussis cases a trend of increasing incidence has been noted in El Paso that mirrors similar trends throughout Texas and the rest of the United States.

Beyond a recently observed increase in pertussis incidence, public health workers in El Paso have little quantifiable information to characterize the nature of ongoing pertussis transmission. To examine how providers may play a role in the rising pertussis incidence noted in the region and to better understand the process of diagnosing and reporting pertussis cases, an assessment of clinician knowledge, attitudes, and practices was conducted among El Paso physicians regarding pertussis clinical management. The survey also aimed to examine factors believed to influence diagnostic testing practices, determine whether behaviors differ by state of knowledge about pertussis, and to ultimately help facilitate evidence-based interventions designed to increase knowledge and awareness of pertussis clinical management among El Paso physicians.

Findings from the survey indicate that despite relatively extensive experience at diagnosing pertussis among survey respondents, questions targeting pertussis knowledge revealed gaps in several areas. Physicians generally had a good knowledge of pertussis symptoms and state reporting requirements for pertussis cases, but often had misconceptions about what public health officials do with reported information and incorrectly believed that serology or clinical judgment can be used to confirm a case of pertussis infection.

Results also revealed that pertussis knowledge is not strongly associated with diagnostic testing practices, while primary clinical specialty, practice setting, and country of medical education are all more strongly associated with pertussis testing behavior by providers. Unfortunately, these predictors do not provide an easy opportunity for behavior change and are not characteristics that are amenable to intervention. While they are helpful for informing and targeting interventions designed by public health practitioners and researchers, knowledge will likely continue to be an important component of any physician interventions targeting the clinical management and enhanced surveillance of pertussis.

This study generally found physicians in El Paso to have reasonable amounts of pertussis-related knowledge, although significant gaps exist in areas such as pertussis case definitions, case reporting and subsequent action by public health workers, and diagnostic testing. A number of clinicians utilize inappropriate diagnostic tests to confirm pertussis infection, negatively affecting pertussis surveillance and investigation in the region. As a result, there are many existing opportunities for future research and intervention among El Paso physicians in regard to improved clinical management of pertussis. Improved clinical management will become an increasingly important priority in El Paso as pertussis incidence continues to rise in the region.

Recommendations discussed include further research to confirm the extent of any relationship between pertussis knowledge and behavior, as well as to identify additional factors that simultaneously predict testing behaviors and offer feasible opportunities for intervention. In addition, qualitative research, including focus groups or interviews, may serve as useful tools to identify existing barriers to the transition of knowledge into practice by providing an open forum for discussion. Local health departments may find value in structuring future interventions that foster open discussion between clinical and public health professionals.

INTRODUCTION

Pertussis is an infectious respiratory disease that remains endemic in the United States despite a widespread childhood vaccination program. Also known as whooping cough, pertussis is an acute infection characterized by severe and long-lasting cough caused by the gram-negative *Bordetella pertussis* bacterium. Pertussis has historically been a major cause of morbidity and mortality and remains a significant cause of infant mortality worldwide. Although primarily affecting unvaccinated individuals, pertussis can also present among previously-vaccinated individuals among whom immunity has waned. Infection with pertussis presents a particular risk for severe disease and complications among infants, while older children, adolescents, and adults generally present with a prolonged chronic cough illness.

Recent scientific evidence has indicated that protection from DTaP vaccine decreases over time, providing little to no protection 5 to10 years after the last dose. Similarly, it is now believed that immunity accrued from natural infection is not lifelong. Therefore, physicians are advised to consider pertussis in patients with a compatible clinical presentation, regardless of age, vaccination status, or prior disease history.

The state of Texas requires that all laboratory-confirmed and clinically-suspected cases of pertussis be reported to the local or regional health department or to the Texas Department of State Health Services (TX DSHS) Infectious Disease Control Unit within one business day. Public health organizations rely heavily on physicians to quickly and accurately report cases of pertussis so that they can accurately characterize the increasing incidence of pertussis, implement meaningful policies, conduct accurate epidemiologic surveillance, and conduct responses as appropriate. Despite this heavy reliance on public health reporting, cases of pertussis in El Paso are believed to be heavily underreported, in part due to existing barriers to health care access faced by the general population along the United States-Mexico border, and failure by physicians to consider pertussis in the differential diagnosis of patients with cough.

While several diagnostic methods are available to confirm pertussis infection, many lack sensitivity and/or require repeat testing or extended incubation times for test results. For this reason, the state of Texas only considers a pertussis diagnosis to be confirmed if tested by bacterial culture or polymerase chain reaction (PCR). Serology (antigen and antibody testing) and Direct Fluorescent Antibody (DFA) are not considered confirmatory for pertussis infection. Serology is not currently standardized in the United States, and DFA has variable specificity and low sensitivity, making them unreliable for laboratory confirmation of pertussis. It is important that physicians collect appropriate specimens from clinically-suspected cases of pertussis and order appropriate diagnostic tests to be performed by commercial laboratories because inappropriately-tested cases may not be included in counts of pertussis cases by local, state, and federal public health agencies.

The state of Texas, in line with the rest of the United States, has observed an increased incidence of pertussis across all age groups from 2006 to 2013, with the incidence rate per 100,000 increasing three-fold among infants less than 1 year of age and eight-fold among children aged 10-14 years, respectively. The trend of increasing incidence is mirrored in El Paso, Texas. The annual number of pertussis cases reported in El Paso has increased from approximate 2-9 cases per year prior to 2011 to 65-70 cases per year after 2012, corresponding to an increase in annual incidence rate from 1.2 cases per 100,000 residents to 8.8 cases per 100,000 residents.

Beyond the noted sharp increase in pertussis incidence, local, state, and federal public health organizations in the United States have little quantifiable information to characterize the nature of ongoing pertussis transmission. The geographic position of El Paso at the junction, of the U.S. states of Texas and New Mexico and along the United States-Mexico international border, in conjunction with the low-resource and binational character of the region

complicate the collection of data, conduction of epidemiologic surveillance, and implementation of public health action.

For these reasons, an assessment of clinician knowledge, attitudes, and practices regarding pertussis clinical management among El Paso physicians was conducted to better understand the process of diagnosing and reporting cases of pertussis. Additional aims of the study were to examine factors that influence physician testing practices, determine whether behaviors differ by state of knowledge about pertussis, and to ultimately help facilitate evidence-based interventions designed to increase knowledge and awareness of pertussis clinical management among El Paso physicians.

Survey Administration and Population

The population of physicians to be surveyed was targeted to include currently-practicing physicians who were most likely to encounter and diagnose a case of pertussis, including the following specialties:

- General Practice
- Family Medicine
- Internal Medicine
- Pediatrics
- Obstetrics/Gynecology
- Allergy/Immunology

Due to time and budgetary constraints, only physicians in the central regions of El Paso, as defined by ZIP code, were surveyed. Using a database of El Paso physicians from the El Paso Department of Public Health (DPH), an initial list of 118 office locations employing at least one physician of eligible specialty was compiled.

Of the 118 business addresses identified as eligible locations to distribute the survey, only 71 were successfully contacted. Many of the remaining 47 addresses listed were residential addresses, or the practice had gone out of business or moved to a new location. The 71 office locations where the survey was distributed employed a total of 123 physicians.

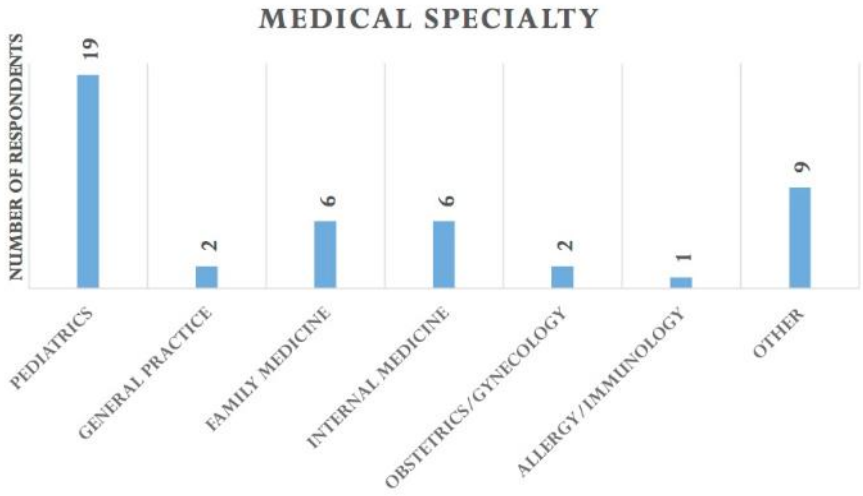
Of the 123 physicians to whom the survey was successfully distributed, a total of 53 surveys were returned, corresponding to a response rate of 43%. From the returned surveys, 45 respondents were deemed eligible for further data analysis. The remaining 8 participants indicated that they were not currently practicing clinical medicine, or did not intend to continue practicing medicine for at least one year post-survey.

PHYSICIAN DEMOGRAPHICS

Self-Reported Professional Demographics

We collected numerous self-reported demographic characteristics from participating physicians, including primary specialty practiced, clinical practice settings, length of medical career, and the country of medical education.

Medical Specialties of Survey Participants (n=45)

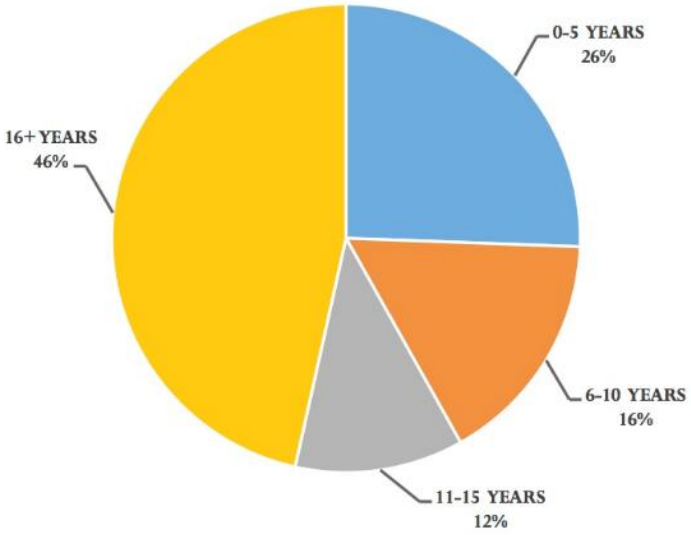


Clinical Settings Where Respondents Practice (n=45)

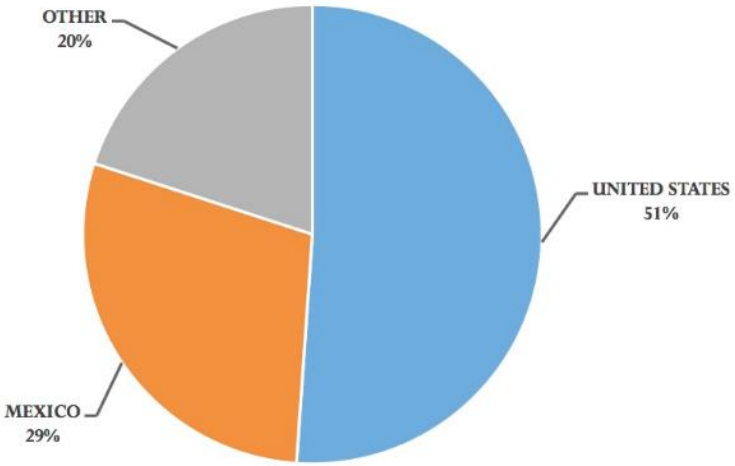
Practice Setting	N*	%*
Outpatient Setting	41	91.1
Inpatient/Hospital Setting	20	44.4
Emergency Department/Urgent Care	5	11.1
Intensive Care Unit	10	22.2
Community Health Center	3	6.7

*Participants could indicate that they worked in multiple settings

Length of Medical Career Excluding Residency (n=43)



Country of Medical Schooling for Survey Respondents (n=45)



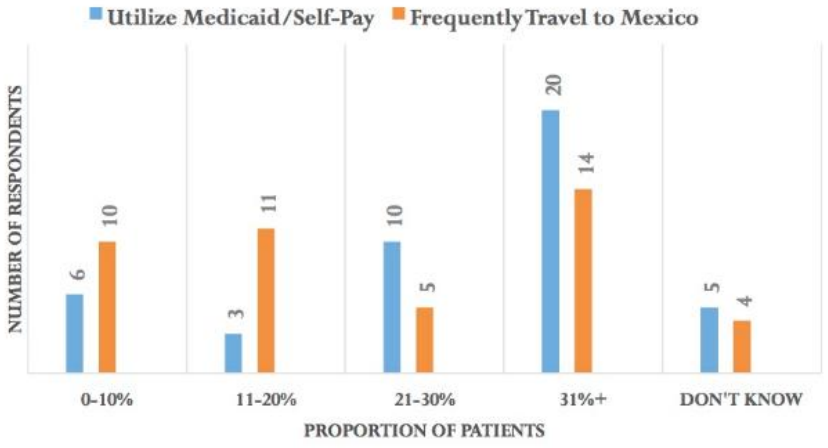
Patient Demographics

Patient Demographics as Estimated by Physicians

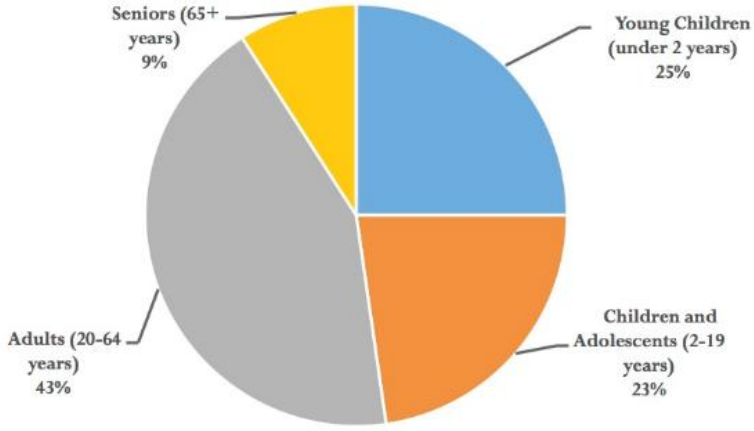
We collected information on the demographic profiles of patients treated by participating physicians. Physicians were asked to estimate and self-report the proportion of patients that utilized self-payment or Medicaid to pay for services; the proportion of patients who frequently traveled to, lived in, or worked in Mexico; as well as patients' ages.

The proportion of patients that insured with Medicaid or who choose to self-pay served as a proxy measure of patient socioeconomic status in later analyses, while the proportion of patients frequently traveling to Mexico was used as a proxy measure of patient mobility.

Proportion of Patients that Self-Pay for Services and Frequently Travel to Mexico (n=44)



Age of Patients Treated by Survey Respondents (n=44)



PERTUSSIS EXPERIENCE

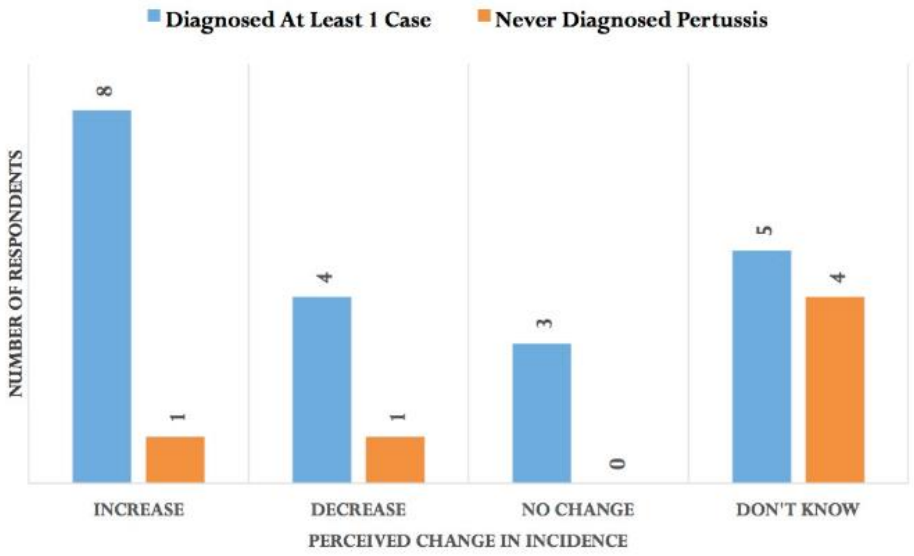
Physician Experience with Pertussis

We collected information on the number of pertussis cases that survey participants had previously diagnosed during the course of their careers, as well as their perceptions regarding the change in annual pertussis incidence over the past 5 years.

Number of Diagnosed Pertussis Cases by Physician (n=44)

Number of Diagnosed Cases	N	%
0 cases	22	50.0
1-5 Cases	17	38.6
6+ Cases	5	11.4

Perceived Change in Annual Incidence of Pertussis Over Past 5 Years



PERTUSSIS KNOWLEDGE

Identifying Gaps in Pertussis Knowledge

Survey participants were asked a number of questions designed to assess pertussis-related knowledge in several areas, including pertussis case definitions and symptoms, appropriate diagnostic testing procedures, and actions taken by public health practitioners when a case has been reported. Correct answers to knowledge questions were taken from 2014 Epi Case Criteria Guide and the Guidelines for Investigation and Control of Invasive, Respiratory, Foodborne, and Vaccine-Preventable Diseases, both published by the TX DSHS. Knowledge was scored on a 25-point scale, with one point awarded for each correct answer. Based on their knowledge score, physicians were then classified as having good, fair, or poor knowledge.

Responses to Pertussis Knowledge Questions

Pertussis knowledge questions and possible answers	N	Correct Response	Percent Correct
What is the minimum cough duration associated with pertussis? (N=36)			
7 days	11		
10 days	5	14 days	22.2
14 days	8		
21 days	12		
Other than cough duration, which of the following symptoms may be associated with pertussis? * (N=39)			
Paroxysms of coughing	35	Yes	89.7
Sneezing and runny nose	22	Yes	56.4
Inspiratory "whoop"	35	Yes	89.7
Vomiting	31	Yes	79.9
Apnea	24	Yes	61.5
Fever	26	Yes	66.7
Is immunity following pertussis vaccination lifelong? (N=39)			
Yes	0		
No	36	No	92.3
Don't Know	3		
Is immunity following pertussis infection lifelong? (N=39)			
Yes	1		
No	29	No	76.3
Don't Know	8		
Which of the following statements is correct regarding reporting of pertussis to public health in Texas? (N=38)			
Pertussis is not a notifiable disease in Texas	1		
Pertussis reporting should occur with laboratory-confirmed cases only	5		
All suspected and confirmed cases should be reported in 24 hours	32	All suspected & confirmed cases should be reported in 24 hours	84.2
Pertussis should be reported only if it is present in infants less than 1 year of age	0		

*Respondents could select multiple answers

Responses to Pertussis Knowledge Questions (cont.)

Pertussis knowledge questions and possible answers	N	Correct Response	Percent Correct
When a case of pertussis is reported the health department may take which of the following actions?* (N=44)			
Tally the case for statistical purposes	26	Yes	59.1
Call the patient or family to identify contacts at risk of getting the disease	34	Yes	77.3
Prescribe antibiotics for contacts	27	No	61.4
Go to patient's house and obtain samples from an untested or asymptomatic patient	22	No	50.0
Report the case electronically to the CDC	25	Yes	56.8
Which of the following methods are confirmatory for the purposes of public health reporting of pertussis?* (N=41)			
Clinical judgment alone is sufficient	30	No	73.2
Culture	25	Yes	61.0
PCR	28	Yes	68.3
Serology	21	No	51.2
Direct Fluorescent Antibody (DFA)	26	No	63.4
Which of the following scenarios are sufficient to confirm pertussis diagnosis?* (N=36)			
Cough illness of two weeks with paroxysms of coughing, inspiratory whoop, post-tussive vomiting, or apnea	13	No	36.1
Acute cough of any duration with isolation of *B. pertussis* from clinical specimen	25	Yes	69.4
A case that meets the clinical case definition with *B pertussis*-specific nucleic acid detected by PCR	23	Yes	63.9
A case that meets the clinical case definition with *B. pertussis* antibodies detected serologically	20	No	55.6
A case that meets the clinical case definition and is epidemiologically linked to a laboratory-confirmed case	18	Yes	50.0

*Respondents could select multiple answers

Pertussis Knowledge Score†	
(mean ± SD)	14.64 ± 4.51

† Scores may range from 0-25

Classification of Physician Pertussis Knowledge By Knowledge Score (n=45)

Knowledge Classification	N	%
Good*	22	50.0
Fair†	17	38.6
Poor‡	5	11.4

* Corresponds to a knowledge score ≥20, or at least 80% of questions answered correctly
† Corresponds to a knowledge score of 13-19, or 50-80% of questions answered correctly
‡ Corresponds to a knowledge score ≤12, or less than 50% of questions answered correctly

Gaps Identified in Pertussis Knowledge

Several gaps were identified in provider knowledge of pertussis clinical management. Less than a quarter of respondents were able to correctly identify the minimum cough duration required to fit the TX DSHS pertussis case definition. A majority of respondents were able to identify paroxysms of coughing and inspiratory whoop as symptoms associated with pertussis infection, while little more than half believed that more nonspecific symptoms such as fever, apnea, and sneezing or runny nose could be associated with pertussis infection. It should be noted that since the time that this survey was administered the TX DSHS pertussis case definition has been revised to remove fever and sneezing or runny nose.

When asked what types of laboratory testing are confirmatory for the purposes of public health reporting, nearly half of respondents incorrectly indicated that serologic testing is confirmatory of pertussis infection, while nearly a quarter of respondents felt that clinical judgment alone was sufficient to confirm pertussis infection. When participants were presented with five scenarios describing various methods to confirm a suspected case of pertussis and asked to describe each scenario as appropriate or inappropriate to confirm pertussis infection according to Texas state guidelines, fewer than two-thirds of respondents were able to correctly identify whether any given method was confirmatory, and no respondent correctly identified all five scenarios as confirmatory or non-confirmatory.

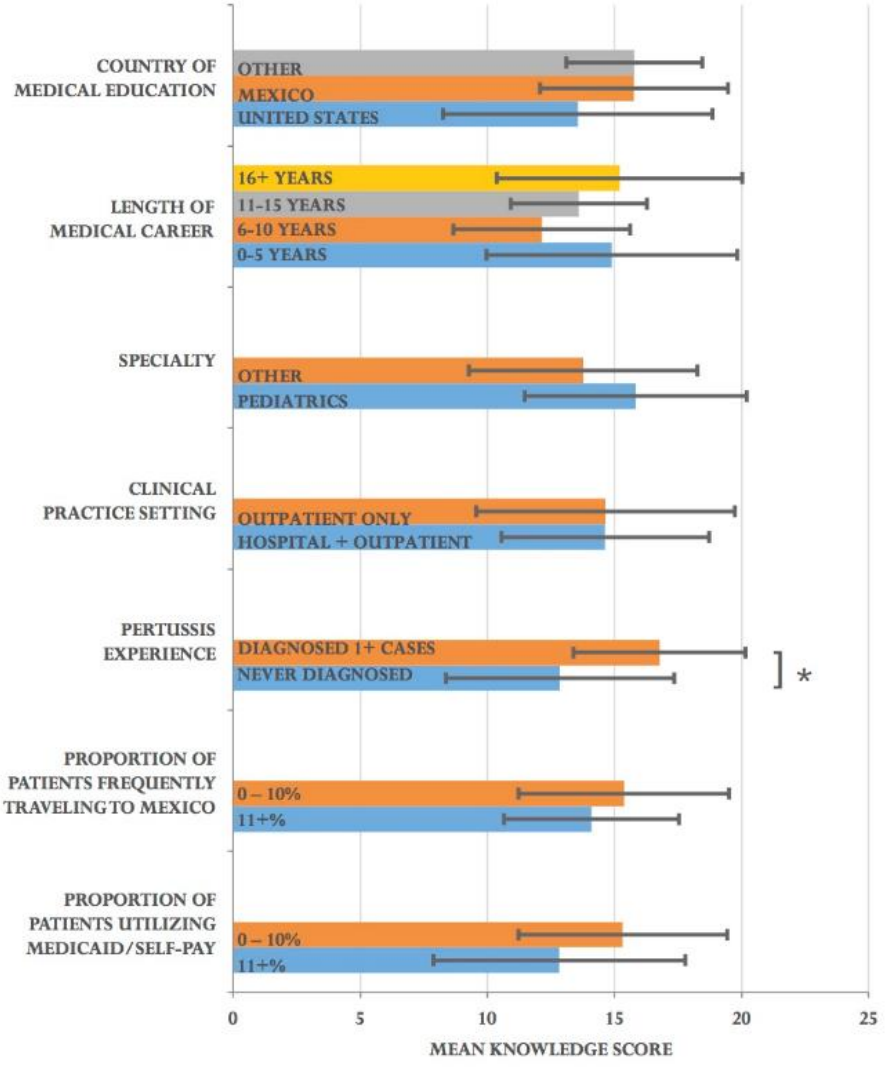
Finally, it was determined that respondents generally had low levels of knowledge regarding the actions that the local health department can take once a case of pertussis has been reported. While a majority of respondents was able to correctly identify that the health department works to identify contacts at risk of exposure, little more than half knew that the health department keeps a tally of cases of statistical purposes and then reports case information to the CDC. A large proportion of respondents incorrectly believed that the health department is able to proactively seek out contacts deemed to be "at risk" to obtain samples for pertussis testing and prescribe antibiotics.

Just over a tenth of participants were classified as having good knowledge of pertussis clinical management. A large proportion of survey respondents was classified as having fair knowledge. These physicians generally had a good knowledge of pertussis symptoms and state reporting requirements for pertussis cases, but often had misconceptions about what public health officials do with reported information and incorrectly believed that serology or clinical judgment can be used to confirm a case of pertussis infection.

Physician Knowledge Scores Across Demographic Characteristics

Average knowledge scores for survey participants were compared across multiple self-reported professional characteristics, patient demographic characteristics, and pertussis experience

Mean Pertussis Knowledge Score by Demographic Characteristics



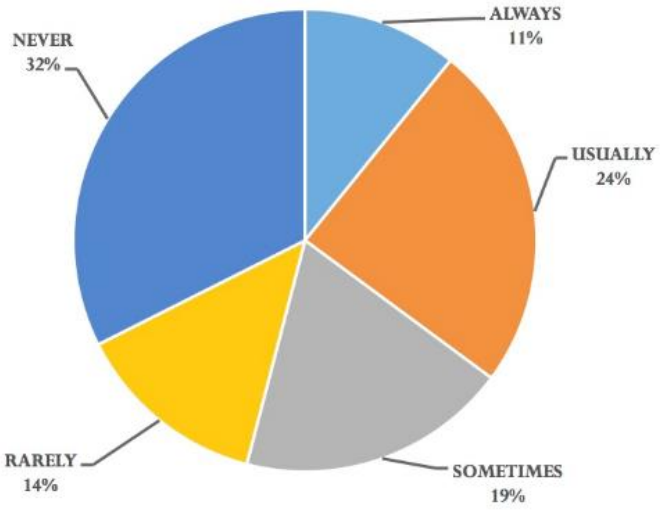
*p<0.01

PERTUSSIS TESTING & REPORTING PRACTICES

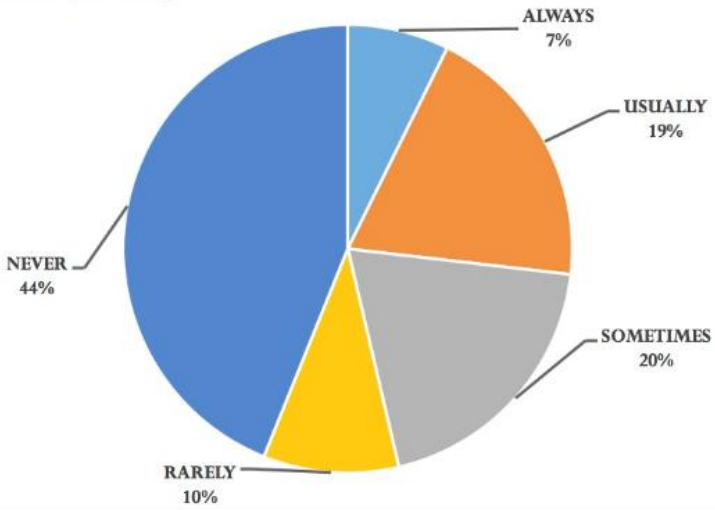
Clinical Management Behaviors among Physicians

In addition to collecting information on physician knowledge of pertussis clinical management, we asked physicians to self-report testing practices when faced with a suspected case of pertussis infection, as well as case reporting behaviors.

Frequency of PCR and Bacterial Culture Utilization to Confirm Pertussis Infection (n=37)



Frequency of Serology Utilization to Confirm Pertussis Infection (n=41)

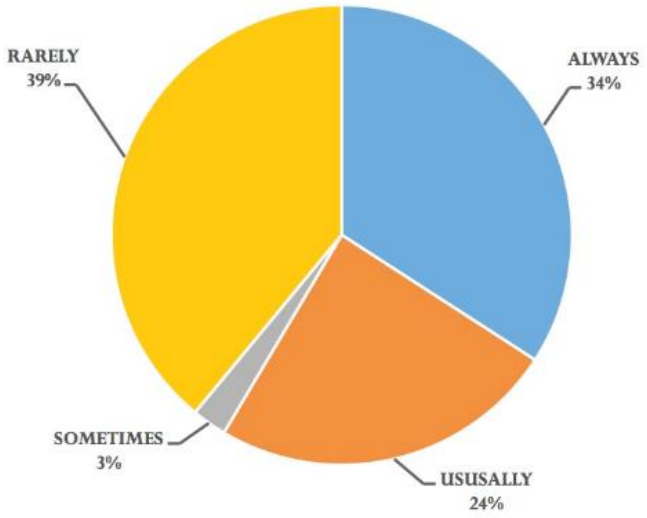


Reasons for Utilizing Serologic Testing in Lieu of PCR or Bacterial Culture (n=24)

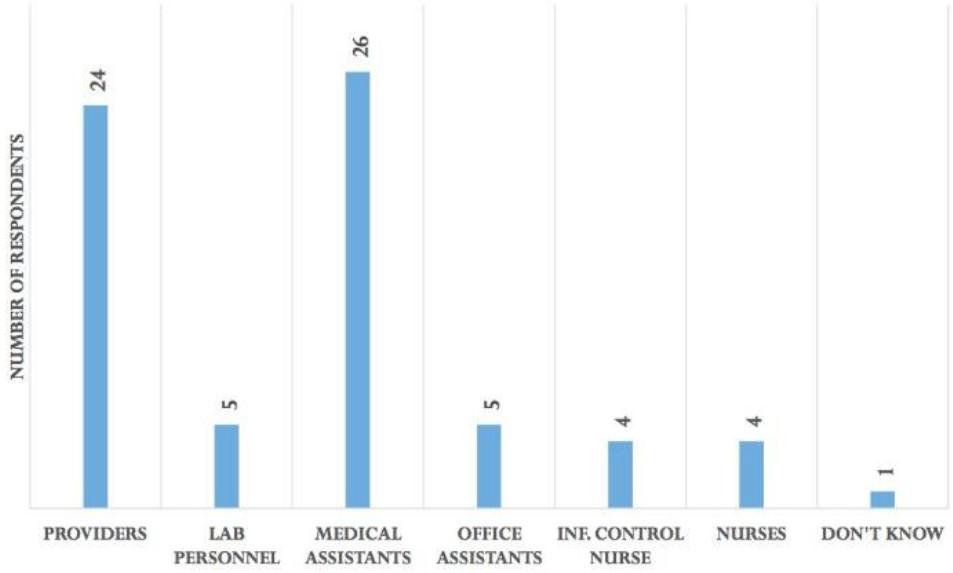
Reason*	N	%
Collecting a nasopharyngeal swab is difficult	3	12.5
Collecting a nasopharyngeal swab takes too much time	1	4.2
I'm not comfortable taking a nasopharyngeal swab	1	4.2
Patients are more likely to accept phlebotomy than a nasopharyngeal swab	5	20.8
It's easier to perform phlebotomy than a nasopharyngeal swab	6	25.0
The patient presented late in the course of illness	18	75.0
Serologic testing is less expensive than other methods	0	0.0
Other	1	4.2

*Respondents could select multiple answers

Self-Reported Frequency of Suspected and Confirmed Pertussis Case Reporting (n=41)



Employees Responsible for Reporting Cases of Notifiable Conditions (n=45)*



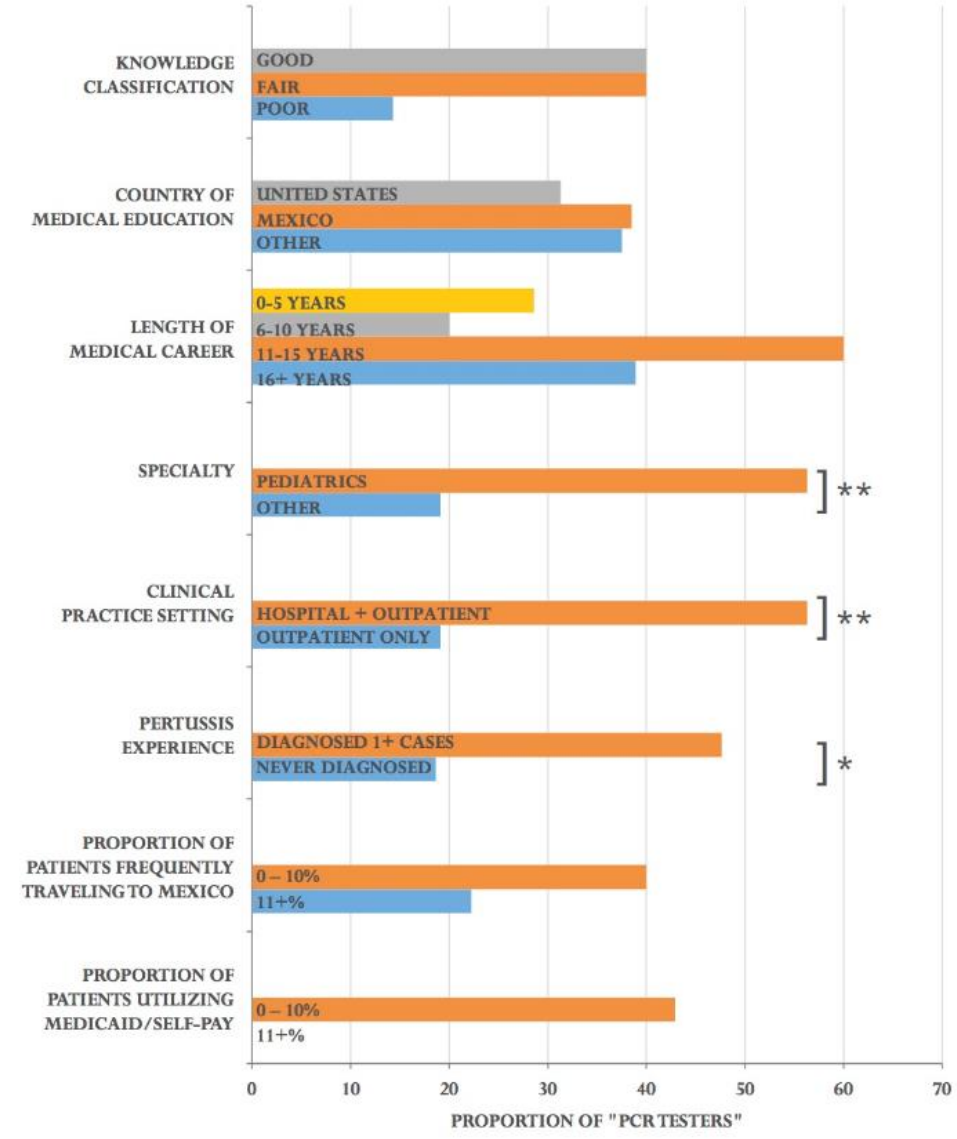
*Respondents could select multiple answers

Associations between PCR and Serology Testing Practices, Physician Knowledge, and Demographics

We dichotomized physicians as "PCR testers" and "PCR non-testers" based on the frequency with which they elected to conduct either PCR or culture to confirm suspected pertussis infection. Those that indicated "usually" or "always" conducting PCR or culture were classified as "PCR testers," while the remainder were classified as "PCR non-testers." Participants were also dichotomized as "serology testers" or "serology non-testers" based on the same criteria.

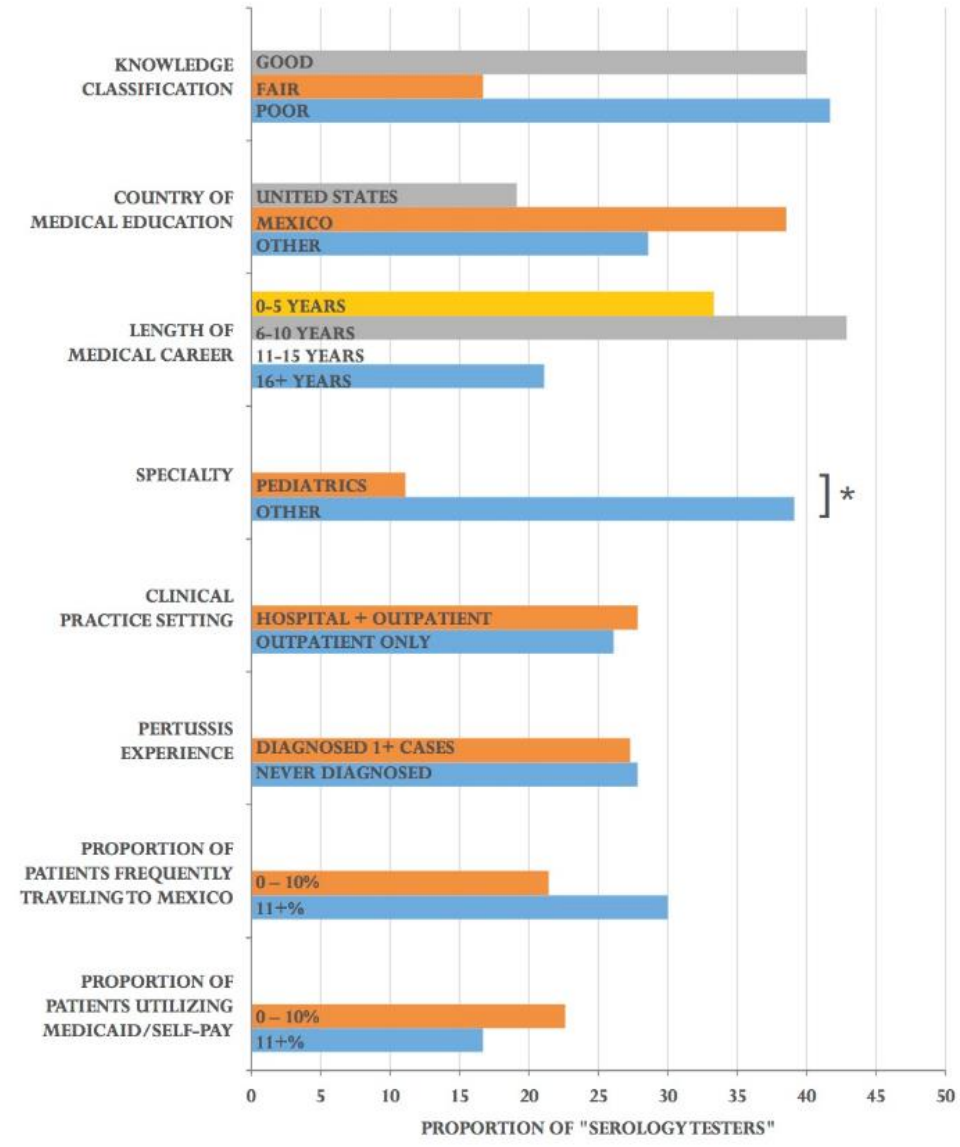
We then examined physicians across knowledge categories and across several demographic characteristics to determine whether the proportion of "PCR testers" differed significantly. The same was done with "serology testers."

Proportion of "PCR Testers" Across Select Demographic Characteristics



*p<0.1
**p<0.05

Proportion of "Serology Testers" Across Select Demographic Characteristics



*p<0.1

Pertussis Knowledge, Attitudes, and Practices | 3/3/15

18

KNOWLEDGE AS A PREDICTOR OF BEHAVIOR

Physician Knowledge as a Predictor of Testing Behavior

Multivariate logistic regression was performed to more closely examine the relationship between knowledge and PCR and serology testing behaviors while controlling for effect modification and confounding by other factors. Final models indicated that physicians with fair and good knowledge had greater odds of utilizing PCR testing to confirm suspected pertussis infection than physicians with poor pertussis knowledge when controlling for medical specialty, clinical practice setting, and pertussis experience, although this relationship was not significant. Physicians with poor pertussis knowledge were also found to have greater odds of utilizing serologic testing compared to physicians with fair or good knowledge when controlling for medical specialty and pertussis experience, although again it should be noted that the relationship was not found to be significant.

Other Factors Identified as Predictors of Pertussis Testing Behavior

While it was clear that knowledge alone did not strongly predict pertussis diagnostic testing practices, multivariate logistic regression models were used to identify other factors that are significantly associated with testing behavior. It was found that both medical specialty and clinical practice setting were significantly associated with the odds of physicians utilizing PCR testing to confirm pertussis infection. Pediatricians had odds of ordering PCR or bacterial culture that were eight times greater than their colleagues of non-pediatric specialties, when controlling for clinical practice setting. Similarly, clinicians who practiced medicine in an inpatient hospital setting, emergency department, or ICU had odds of ordering PCR that were seven-fold higher than the odds among physicians who worked solely in outpatient setting or community health center when controlling for specialty.

Similarly, two predictors remained significantly associated with serology testing practices upon examination via logistic regression. Clinical specialty was again found to be significantly associated with pertussis management practices, with pediatricians having reduced odds of utilizing serologic testing relative to non-pediatricians when controlling for other significant factors. Also of note, the country where physicians received their medical education was found to be marginally associated with the odds of utilizing serology to confirm pertussis infection. When controlling for specialty, physicians who had been trained in Mexico had odds of performing serologic testing that were 5.6 times greater than their U.S.-trained colleagues. Physicians trained at other foreign medical schools also had higher, though not significantly so, odds of ordering serologic testing to confirm suspected pertussis infection relative to clinicians educated in the United States.

CONCLUSIONS & RECOMMENDATIONS

Strengths and Limitations

This assessment provides local, state, and federal public health agencies in El Paso with much-needed information about the current state of physician knowledge, attitudes, and practices regarding pertussis-related clinical management in the region. While the El Paso DPH has anecdotal evidence suggesting that inappropriate use of serologic testing to confirm pertussis infection is widespread, it has not previously had access to data regarding clinician knowledge of pertussis disease and diagnostic practices, knowledge of pertussis reporting guidelines in the state of Texas, case reporting practices, and attitudes regarding pertussis case reporting. This information is essential for public health practitioners in the region to better understand the factors that influence pertussis diagnostic behaviors and the timely reporting of notifiable conditions, identify gaps in pertussis knowledge among the city's providers, and inform targeted and effective interventions designed to address shortcomings in the clinical management of a rapidly-reemerging infectious disease.

Many studies that utilize a KAP assessment describe the current state of knowledge, attitudes, and practices in a population without further exploring the relationship between knowledge and behavior. Studies that do further explore the association between knowledge and practice, however, generally do so in the context of evaluating the effectiveness of a knowledge-based intervention using baseline and follow-up studies. The use of maximum likelihood logistic regression models in a piloted study, however, may help to inform efforts prior to implementation and provide insight into whether knowledge-based interventions have the potential to succeed, while also identifying additional factors that may influence their success. This method also allows researchers to identify populations and aspects of pertussis clinical management that may benefit most from future interventions designed by state and local public health services.

While this assessment has the potential to inform intervention efforts prior to implementation, it must also be noted that the study had several important limitations, including aspects of survey design and administration, continually evolving pertussis case definitions, as well as a small sample size. Knowledge may be best measured using open-ended questions so that participants are required to provide the information without encountering potentially leading questions or restrictive choices. However, due to concerns regarding low participation and response rates among physicians, it was decided to make the survey as simple as possible by reducing the amount of necessary write-in components, maximizing the number of questions that were multiple choice format, and minimizing the number of total questions. This necessitated the compression of multiple behavior-based questions into a single multiple choice question in several cases.

The study was also limited by the methods of survey distribution and collection. Because offering incentives to complete the survey were beyond the scope and financial constraints of the project, there was much concern regarding the sampling of physicians, who generally have very low response rates to KAP surveys. In an effort to maximize respondent participation, it was elected to distribute paper copies of the survey in a marked envelope to eligible participants rather than distribute an online version of the assessment via email. The entire city of El Paso encompasses over 250 square miles and inclusion of physicians throughout the entire area was not feasible for this project. By conducting a survey of convenience and excluding physicians in the upper West Side and the eastern portion of the city, we likely excluded many physicians who have a greater degree of experience with pertussis. A 2013 report published by the El Paso DPH suggests that a majority of reported pertussis cases occurred in outer regions of the city, particularly in the northern and eastern ZIP codes.

Accurate assessment of provider knowledge of pertussis clinical management, particularly knowledge of pertussis case definitions and associated clinical symptoms, is difficult to measure due to continually evolving guidelines pertaining to the classification of pertussis. At the time that the survey was conducted, the TX DSHS Guidelines for Investigation and Control of Invasive, Respiratory, Foodborne, and Vaccine-Preventable Diseases, which serves as a tool to help local and regional public health staff with surveillance activities and investigations, defined a case of pertussis as "a cough illness lasting at least 14 days AND at least one of the following additional symptoms and without other apparent case (as reported by a health professional): Paroxysmal cough, inspiratory 'whoop,' post-tussive vomiting, sneezing and runny nose, fever, or apnea with or without cyanosis if under 1 year old." As of January 2014, however, the case definition of pertussis has been revised to exclude fever and sneezing or runny nose. In addition, there is much discussion as to whether the case definition should be further refined to include a cough illness of any duration, particularly among young infants, and future revision of the case definition appears likely.

In addition to limitations in study design, administration, and pertussis case definitions, the assessment was also limited by a small sample size. The survey analyses included just 45 physicians, limiting the statistical power. As a result, it was likely difficult to detect true relationships between variables of interest among sub-samples in the study. Additional studies, including baseline and follow-up of any knowledge-based interventions, will need to include a larger sample to verify the relationships of interest between knowledge and behavior. This may be more easily accomplished by the El Paso Department of Public Health, which likely has access to greater resources and influence among physicians in the region than the CDC.

Conclusions

Physician knowledge of pertussis clinical management was not found to be significantly associated with pertussis testing practices as originally hypothesized. Even controlling for potentially confounding demographic characteristics, such as medical specialty, clinical practice setting, and pertussis experience, knowledge was not found to be strongly associated with testing behavior. However, knowledge may not be the best predictor of pertussis testing behavior by providers. Primary specialty, clinical practice setting, and the country of medical education were all found to be significantly associated with either PCR testing behavior or serology testing behavior. Unfortunately, these predictors do not provide an easy opportunity for behavior change and are not characteristics that are amenable to intervention. While they are helpful for informing and targeting interventions designed by public health practitioners and researchers, knowledge will likely continue to be an important component of any physician interventions targeting the clinical management and enhanced surveillance of pertussis.

This study generally found physicians in El Paso to have reasonable amounts of pertussis-related knowledge, although many had significant gaps in areas such as pertussis case definitions, case reporting and subsequent action by public health workers, and diagnostic testing. Many physicians continue to utilize inappropriate diagnostic tests to confirm pertussis infection, negatively affecting pertussis surveillance and investigation in the region. As a result, there are many existing opportunities for future research and intervention among El Paso physicians in regard to improved clinical management of pertussis. While education is needed in all groups, targeting interventions aimed at improving the utilization of PCR to confirm suspected cases of pertussis is especially needed for physicians of non-pediatric specialties who may be less likely to suspect and diagnose pertussis infections. Improved clinical management will become an increasingly important priority in El Paso as pertussis incidence continues to rise in the Paso del Norte region, the state of Texas, and the United States as a whole.

Recommendations

Further research will be necessary to confirm the extent of any relationship between pertussis knowledge and behavior, as well as to identify additional factors that better predict pertussis testing behavior and offer feasible

opportunities for intervention. Similar assessments with a larger sample size may provide greater statistical power with which to detect a true relationship. Further studies examining the associations between specific facets of pertussis knowledge, such as knowledge of pertussis symptoms and case definitions, pertussis detection, pertussis treatment, or DTaP/Tdap vaccination, and various clinical management behaviors may also be worthwhile. The current study does not differentiate between specific aspects of pertussis knowledge beyond identifying existing gaps in knowledge.

Additional qualitative research, such as focus groups or interviews, should serve as a useful tool to identify existing barriers to the transition of knowledge into practice by providing an open forum for discussion that is not available in multiple-choice surveys. Despite the unavailability of free response space on this survey, several surveys were returned with either comments expressing a perceived lack of support of clinicians by the El Paso Department of Public Health or suggestions for how to improve communication between medical providers and public health agencies. The local health department may find value in structuring future interventions in a manner that fosters open discussion between clinical and public health professionals to address any real or perceived lack of support among clinicians. This may also serve to improve physician participation in future surveillance, investigations, and assessments carried out by CDC,TX DSHS, or the El Paso DPH in the region.

Until further research is done to identify factors that best predict pertussis testing behaviors, interventions in El Paso aimed at improving clinical management of pertussis should focus on improving pertussis knowledge among providers who are most likely to encounter cases of pertussis, including clinicians who may not expect to come across cases of pertussis but are likely to encounter upper respiratory infections in individuals of any age. Although improved knowledge does not appear to be significantly associated with pertussis testing practices according to this study, better knowledge among clinicians may in fact be associated with other pertussis clinical management behaviors, such as case reporting, treatment and appropriate use of prophylaxis, or pertussis vaccination. In cases where resources are limited, interventions should be targeted to groups identified as most likely to utilize pertussis confirmatory testing inappropriately, including physicians who specialize in non-pediatric medicine, practice in outpatient offices or community health centers, or who received their medical education from a Mexican medical school. Evaluation should be conducted regardless of the scope of the intervention to determine the effectiveness of the intervention and inform future research.