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Tuberculosis Contact Investigation in an Urban Omaha High School

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TUBERCULOSIS CONTACT INVESTIGATION IN AN URBAN OMAHA NEBRASKA HIGH SCHOOL

by

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In November 2016, a 15-19 year old high school student was diagnosed with active pulmonary Tuberculosis (TB) and reported to the Douglas County Health Department (DCHD) in Omaha, Nebraska. A contact investigation led the health department to a local urban high school with a diverse and mobile population. A modified point of dispensing (POD) clinic was determined to be the efficient method to test the 196 faculty and students that were exposed to the index case. Emergency response coordinators (ERC's) at DCHD adapted the POD dispensing plan with an embedded Incident Command System (ICS) to fit a smaller incident as well as for the unique needs of a public health emergency. The first clinic was held on December 6th - 9th. A total of 173 faculty and students were tested resulting in the identification of seven latent positives. An epidemiological investigation showed all latent are not related to the index case and had other risk factors for their latent TB. The second clinic was held February 21st – 22nd and 163 of the 189 identified contacts were tested. There was one student who tested positive after initially testing negative the first time. Therefore, it is possible this was due to the exposure to the index case, also known as a conversion. In conclusion, adaption of the POD dispensing plan worked very well for the DCHD in the contact investigation of the TB case at this urban high school. This investigation allowed the DCHD to implement and modify POD plans, improve coordination between multiple divisions within the department and successfully limit the spread of TB to the community.

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Chapter 1: Introduction

Tuberculosis (TB) is an infection that is caused by the *Mycobacterium tuberculosis* bacteria. This bacterium is spread from person to person and settles in the lungs, most frequently, and either becomes active TB disease or latent (dormant) (World Health Organization, 2016). TB has been on a general decline in occurrence in the United States since the early 1990's, however, for the first time since the 1990's, there has been a 1.6% increase in the number of cases reported in 2015 from 2014 (Centers for Disease Control and Prevention, 2016). In Douglas County, Nebraska the attack rate hit a 5 year high of 3.3 active cases of TB per 100,000 people in 2014, and it only dipped slightly to 2.9 active cases per 100,000 in 2015 versus the attack rate in 2006 which was only 2.8 per 100,000 (Douglas County Health Department, 2017). In November 2016, a high school student aged 15 to 19 years old with active TB case was reported to the Douglas County Health Department. The following paper will discuss a contact investigation conducted at an urban high school in Omaha, Nebraska. This contact investigation brought many issues including the need for education about TB in the community; but also, afforded the DCHD the opportunity to use POD plans they already had in place and modify them for this response.

Background

TB is one of the leading causes of death across the globe. In 2015 10.4 million people became ill with TB and 1.8 million people died. However, the majority of those deaths were in developing countries (World Health Organization, 2016). While it seems very easy to transmit TB, few people in the United States and other developed nations are infected with TB. In 2015, a total of nine thousand five hundred fifty-seven TB cases were reported in the United States. (Centers for Disease Control and Prevention, 2016) and four hundred and ninety-three deaths.

TB can be in two forms of the disease, either active disease or latent (LTBI). The latent form is the dormant form of the disease. Latent TB infection or LTBI means the person is infected with the *Mycobacterium Tuberculosis* bacteria, but does not display any of the symptoms of active disease, nor can they infect anyone with the bacteria (Centers for Disease Control and Prevention, 2017). People with LTBI are a low risk to society unless their LTBI becomes activated due to a susceptible immune system. Treatment protocols such as a medication called Isoniazid can be prescribed to kill the TB bacteria before they have the chance to become activated. Due to lack of resources in countries most affected by TB and often lengthy treatment protocols, many people do not treat their LTBI and instead live with the bacteria in their bodies. “About one third of the world’s population is infected with the tuberculosis (TB) bacteria” (World Health Organization, 2016). This statistic from the World Health Organization shows the immense number of people worldwide who either choose to not complete their LTBI treatment, may not understand the importance of completing this treatment, or may be in developing countries where access to healthcare or other resources is a barrier to treatment.

Screening for LTBI is vital to prevent the conversion of those with LTBI to active TB disease. “More than 80% of cases of tuberculosis in the United States are the result of reactivated latent infection, and nearly all these cases could be prevented by the administration of a course of antibiotic treatment” (Horsburgh & Rubin, 2011). Once a patient develops active disease, the bacteria can be spread through airborne droplets expelled when a person coughs, sneezes, sings, etc. Some common symptoms of active TB disease include: fatigue, fever, night sweats, chills, unintentional weight loss, hemoptysis, and coughing that lasts more than three weeks (Mayo Clinic, 2016). While active TB is most commonly located in the lungs, it can be

located in extra pulmonary sites including the larynx, brain, kidneys, bones, and joints (Centers for Disease Control and Prevention, 2011).

People with extra pulmonary TB are typically not infectious unless they have lesions or an infection located in their mouth or larynx.

While it is not commonly used in the United States, there is a vaccine available to help prevent TB. The vaccine is called the Bacille Calmette-Guérin (or BCG) vaccine, and it was developed by two French scientists named Albert Calmette and Camille Guérin (Luca & Mihaescu, 2013).; The 21-year vaccine development process started in the year 1900 with and culminated in 1921 with the first human dose administered to an infant. To date, this vaccine is still the only TB vaccine available. While it is still administered in TB prevalent areas, particularly to children to prevent severe disease, it has an unreliable efficacy rate for preventing TB infection later in life. "The efficacy of this vaccine varies from 0 to 80% in different populations, with a consistently low efficacy in many tropical regions of the world where the vaccine is most needed" (Brandt, et al., 2002). There is also evidence that after vaccination, even if it is effective in the person who receives the vaccine, it is only effective for 10 years (Sterne, Rodrigues, & Guedes, 1998). Due to these reasons, many nations have discontinued the use of the BCG vaccine.

There are a few different methods to detect TB. The commonly used test in the United States is a Mantoux tuberculin skin test (TST), where a small amount of the solution is placed under the skin on the forearm and read 48-72 hours later. If the person being tested has been exposed to *Mycobacterium Tuberculosis* bacteria, the tuberculin purified protein derivative (PPD) will create a raised red bump on the forearm visible for the healthcare provider to see (Vukmanovic-Stejic, Reed, Lacy, Rustin, & Akbar, 2006). However, this test cannot distinguish between LTBI and active disease; in addition, if a person has received the

BCG vaccine, the TST may result in a false positive TST result. The TST test is a cost-effective solution, but is not very practical in foreign born persons who may have had the BCG vaccine because of a higher risk of false positives.

The most recently developed means of detection for TB is the QuantiFERON Gold blood test. The QuantiFERON Gold blood test was only approved by the CDC in May 2005 to measure the immune systems response to TB proteins in the patient's blood system (Mazurek, et al., 2005). This test does not distinguish between LTBI or active TB, but it does cut down the wait time of 48-72 hours in between the placement of the TST and the read of the test. This is a much more sensitive and specific test, and is the preferred method for those who have received the BCG vaccine as it can differentiate between the different proteins (Centers for Disease Control and Prevention, 2011).

Additional medical tests that can be performed include chest x-rays (CXR) and sputum samples. CXR are taken of the patient who they believe has TB to see if there are any nodules or lesions. CXR and other radiograph tests that show abnormalities are suggestive of TB disease (Centers for Disease Control and Prevention, 2011). Next, if a patient has a positive TST or QuantiFERON, and a suggestive CXR, the patient will complete sputum samples, which is the mucus that comes up with your cough. It is critical to send these samples so that public health officials and physicians alike can diagnose the patient with TB, and later perform antibiotic sensitivities on the culture to ensure the appropriate treatment. The sputum tests are first completed to find AFB smear classification and DNA probe to confirm the presence of the *Mycobacterium Tuberculosis* bacteria. If it is present in the sputum another laboratory process called pulsed-field gel electrophoresis is completed second. This process is a way to get a DNA fingerprint of TB strains and detect differences in

other outbreaks and potentially link outbreaks (Zhang, et al., 1992). Physicians make treatment decisions based on which strain of TB is in the sputum (Mayo Clinic, 2016).

When an active case of TB at an urban high school in Omaha, Nebraska was diagnosed, the Douglas County Health Department (DCHD) initiated a contact investigation immediately. Contact investigations are defined as "…the systematic evaluation of the contacts of known TB patients to identify active disease or latent TB infection (LTBI)" (Fox, Barry, Britton, & Marks, 2012). This contact investigation was launched in November 2016 and has taken multiple levels of DCHD resources and involved intensive coordination with the school, local private hospitals, and outside media organizations to ensure the correct information was getting to the public and families of the students alike.

Chapter 2: Literature Review

Vaccines

Even though vaccines have been a part of medical practice since Edward Jenner and his innovation of using cowpox to create a smallpox vaccine (Stern & Markel, 2005), and are a vital part of public health practice, vaccination rates fell for much of the later part of the 20th century. A movement called the "anti-vaccination" movement swept much of the United States when parents grew concerned regarding a misleading medical study that drew incorrect conclusions between vaccines and autism. Even though this medical study has been proven incorrect numerous times, those who refuse vaccines for their children cite autism and vaccine ingredients as the most common cause of that refusal (Yox & Stokowski, 2015).

In certain parts of the world, such as Japan, mass vaccinations against many types of diseases are common as they are believed to prevent mass outbreaks of illnesses and class cancellation days. One such vaccine that was used was the influenza vaccine. The Japanese government started a universal vaccination program for elementary and junior high aged children (6-15 years old) that was administered by their school doctors. This compulsory program ran from the early 1970's until the early 1990's when it was discontinued by the government because the vaccination program did not seem to have a decisive effect in reducing absenteeism in schools (Kawai, et al., 2011). However, of note, this study did find that influenza outbreaks occurred in the school as well, even when the mass vaccination program was in effect. The effectiveness of the vaccination program may have been more efficient if it had matched the strains of influenza more appropriately each year.

This discontinuation of the mass vaccination program in Japan shows that although vaccines are a major breakthrough in public health practice, certain vaccines such as the BCG are not always 100% effective in the population we are trying to treat. There, it is the job of

the public health professionals to build good public health infrastructure in order to detect active TB cases quickly and be able to respond to them through contact investigations. Japan had a similar compulsory mass vaccination program, but for BCG vaccinations to prevent TB. Because of the BCG mass vaccination programs, before the advent of more sophisticated testing like the QuantiFERON-TB Gold blood test, any contact investigations were bringing up significant amounts of false positives in the TST tests because of the vaccines in the contact's system (Higuchi, Harada, Nobuyuki, Mori, & Sekiya, 2007). This would put a huge resource and time strain on any contact investigation that health departments would try to conduct and they could potentially miss any true positives while focusing on the false positives. The discontinuation of the compulsory mass vaccination program was a logical choice on the part of the Japanese government.

It is possible as well, that even when the vaccines are available, and you make them compulsory for a society, an outbreak may occur anyway. The efficacy of the mumps vaccine is 80%, but also relies on herd immunity to limit outbreaks. This is the situation that unfolded in Orange County, NY when an 11- year-old boy returned from a trip abroad to the United Kingdom where an outbreak of mumps was occurring (Ogbuanu, et al., 2012). The family of the boy felt there was nothing to be concerned about since he had received both doses of the two dose MMR vaccine that is recommended by physicians. During the contact investigation, it was determined during the infectious period of his disease he attended a Jewish Orthodox Summer Camp in New York State where twenty-five cases emerged from members at the camp.

By December of that same year, 392 mumps cases were reported in Orange County, with the highest proportion of cases in the age range of grades Sixth to Twelfth. With that thought in mind, the health department decided a third dose of vaccine for school aged kids

would be best. The third vaccine proved effective in stopping the outbreak. The authors credited this to "the rapid decline in incidence in the target age group suggests a rapid immune response to the third dose that resulted in relatively high mumps vaccine effectiveness" (Ogbuanu, et al., 2012).

This literature review of vaccines surrounding outbreaks shows that even if the BCG vaccine were in common practice in the United States today, there is no evidence that it would be likely to stop an outbreak of TB and the high likelihood that it would interfere with a TST as was shown in the Higuchi article. There are many contributing factors as to why some vaccines work better than others, so while the use of the BCG vaccine is more effective in countries with high incidence of active TB, it is not necessary in countries such as the United States.

High Risk Locations of Outbreaks

Although mass outbreaks can happen in many regions and populations throughout the world, there are certain high risk geographical locations that are more susceptible to infectious disease outbreaks than others. These infectious disease outbreaks are not just limited to TB, but can also include mumps, norovirus, and even STD's such as HIV and AIDS in certain locations and/or populations.

One such high risk geographical location susceptible to infectious disease outbreaks are correctional facilities. In a contact investigation for TB discussion stemming from an inmate at a correctional facility, the authors of the article remark on high probability of inmates of having TB. "Jail inmates have high rates of M. tuberculosis and human immunodeficiency virus (HIV) infection, and are often housed in overcrowded, poorly ventilated buildings" (Bur, et al., 2003). This lack of ventilation ensures that if there is an active case of TB, the index case can easily spread the TB bacteria in the air whenever they

cough. Also, since inmates have a high rate of HIV infection, those with latent infection would have a high rate of activating their latent infection and spreading the disease due to their immunosuppressed status (AIDS.gov, 2011).

Every inmate when coming into a prison is screened for TB. Their initial level of screening is a symptom review asking if they have had a cough, have they lost weight, night sweats or a fever (Federal Bureau of Prisons, 2010). The next steps after that are standard protocols as they would be for anyone who could potentially have TB outside of prison including a CXR, TST, and sputum cultures. However, there are no continual monitoring procedures such as 6 month or yearly TST tests to check inmates for development of TB which would be beneficial in this high-risk population. Since occurrence of TB in the incarnated population is much higher than the general population, it is important to take extra steps to catch the spread of it early, which occasional TST test could do (Baussano, et al., 2010)

Another high risk geographical location that is be susceptible to outbreaks is that of summer camps. Large gatherings of children, from many different backgrounds, it is likely at least some are bringing disease from their families and hometowns with them to this new camp environment. Such an event happened when there was a measles outbreak associated with an international sporting event held in Pennsylvania in August 2007. There were 7 total cases that stemmed from a 12-year-old participant in the camp who was not vaccinated against Measles. The camper stayed in a residential compound at the camp that had dining facilities that were shared with coaches, staff, and 200 players that were from the United States and 8 other countries (Chen, et al., 2010).

With a camp having this many participants, and with participants coming from all over the world, there were a few mistakes that the organizers made. They assumed that

every country has the same vaccination policies as the United States, and did not require that participants have vaccination records present before they could play. Of the 471 children participants at the camp, 193 (41%) lacked immunization records. This also made it very difficult for the health department during the contact investigation to determine who needed to be monitored and who didn't.

Lastly, one of the highest risk geographical locations for outbreaks in children are schools. This is true for children at any age in schools (6-18); and this is true for a few different reasons. First, children in schools can easily transmit infectious diseases via hand to hand contact and surfaces if they do not use proper hand washing techniques. "Confined environments, such as schools, provide opportunities for direct transmission of disease agents between individuals. Because viruses can survive for several hours on human hands and on computer equipment for up to 1 to 2 days, indirect transmission is also frequent" (Lee & Greig, 2010). This would be most frequent in schools with the youngest children such as elementary and pre-k schools. Additionally, children will be bringing in pathogens and bacteria from their outside environment. This could be concerning in young school aged children or recently immigrated and refugee children as they may not have acquired immunity to some viruses such as the chicken pox or measles we here in the United States take for granted (Lee & Greig, 2010).

Lastly, schools across the United States are facing new challenges in the 21st century that are creating issues with infectious disease prevention as well. One of these major issues centers around overcrowding in high schools. "Schools are the most common site reported for community-based outbreaks. Contributing factors include delay in diagnosis, sustained contact, and inadequate ventilation or overcrowding" (Phillips, Carlile, & Smith, 2004). This

overcrowding creates more opportunities for a sick child to interact with more people, more surfaces, and potentially infect more.

But how severe is the overcrowding problem in the United States? According to a 1999 survey done called “Condition of America’s Public School Facilities” noted that 25% or 17,400 schools in the United States face overcrowding issues (National Center for Education Statistics, 2017). With population increases and immigration and refugee numbers increasing since 1999, the number of schools facing overcrowding most likely has increased.

Lack of Education

A significant hurdle that public health practitioners face when trying to limit the spread of TB outbreaks, is trying to educate the public. Often this obstacle leads to patients not completing their course of treatment or, not seeking medical treatment quickly in the first place. The treatment regimens for TB vary per treatment and type of TB, but the shortest treatment is 3 months and the longest is 9 months of daily pills (Centers for Disease Control and Prevention, 2017). For some patient populations that are mobile, do not have a permanent address, or simply do not understand the importance of taking this medication, this could be an overwhelming length of time.

A study done at a public health clinic in the City of San Diego followed a patient population for 6 months on LTBI treatment (medication name Isoniazid) and found that only 64% of the population completed their treatment. The authors also believed had the clinic completed a 9-month regimen, there would have been an even lower rate than the 64% that completed the 6 month regimen (LoBue & Moser, 2003). So, what happened to the just over 1/3 of patients who did not complete their regimens? Unfortunately, they were lost to follow-up and did not complete the study. Therefore, they are still at risk of developing an active TB infection. If cases are left untreated, we are unable to predict who will become

immunosuppressed and their LTBI could become active TB more easily than the average person. “If one assumes that approximately 10 percent of the persons infected with tubercle bacilli will, if left untreated, become cases during their lifetime, one could expect that approximately 20 new cases of tuberculosis would develop in the persons infected by the index patient” (Sacks, et al., 1985). Therefore, it is vitally important for physicians to impress upon LTBI patients the importance of completing treatment regimens, even though they may not feel or see any physical symptoms.

In addition to increasing education in their communities, public health departments face budget constraints and lack of personnel to even get a TB program started in their towns, particularly in smaller health departments. The following example is an international one, but the principals of budget and personnel issues hold true for departments here in the United States. In June 2007, an active TB case was diagnosed in a man on the island nation of Chuuk (Brostrom, et al., 2011). Chuuk is a state in the Federated States of Micronesia which has a low-income level spread across its 600 islands and 1 million square miles. This active TB case was multidrug resistant or MDR, which was something for which this island nation did not have the adequate resources or public health infrastructure to adequately respond to. They put in a request with the World Health Organization’s (WHO)Global Fund to Fight AIDS, Tuberculosis, and Malaria, but were told that due to lack of funding it would take time to get the medication. By July 2008, Chuuk had an additional 20 active MDR cases, and 124 latent cases. In August 2008 funds from the US Department of Interior helped bring second line TB drugs into the country as well as staff with expertise that would help handle this outbreak. Considering it costs an average of $137,000 to treat each case of MDR TB in Chuuk, and the annual TB budget for the country of Micronesia is $170,000, there is a major resource problem when an outbreak occurs. Building up the capabilities and planning before an

outbreak happens could have limited the outbreak that occurred on Chuuk and prevented its duration.

A similar example, was the lack of financial resources during a contact investigation of a TB outbreak at a homeless shelter in Kane County, Illinois. Public health officials identified 24 active TB cases infected from an index case, and treated them at a cost of $204,500 (Dobbins, et al., 2012). However, program resources did not allow the health department to treat the other 146 people who did have LTBI. That is extremely hazardous considering the patient population using the homeless shelter. However, considering the immense cost of certain medications, there was simply no financial way for the department to cover the cost.

In many contact investigations and outbreaks alike, public health agencies have a responsibility to work with the media to ensure that public messaging is providing adequate information. A failure to do so can leave a public health agency rushing and create more work than is necessary to calm public perception and misperceptions of the problem. Such a problem arose during a TB outbreak in an Italian elementary school in November 2008.

When the health department tested the class of the kindergarteners and 34% had a positive TST test, the Italian news media focused heavily on this story and parents demanded the health department move quickly. A young kindergarten age girl was diagnosed with TB and it was soon determined that she acquired TB from her teacher's assistant, who was a 42-year-old woman who had a positive TST result, but did not complete the LTBI medication regimen years ago (Filia, et al., 2011). The authors remarked "Urgency was required because of the school setting, pressure by parents, and media coverage. As in other school-contact investigations, this urgency may have led to excessive screening of low risk persons and difficulties in categorizing contacts by close and casual status" (Filia, et al., 2011). In total,

there were 19 school children with active TB and 43 with LTBI, but there were 851 people tested, many of whom may not have needed to be tested if the health department had the time to educate the parents about LTBI and active TB. However, the fact that the outbreak was in an elementary school and the lack of education about TB made it a headline grabbing story for the Italian news media.

One school of thought is that schools should take a greater responsibility in teaching children about preventing illness and outbreaks, particularly starting in elementary schools. It can be something as simple as covering your mouth and nose when you sneeze, and proper handwashing techniques. To more advanced ideas in middle and high school of explaining infectious disease principles in a class like health class. “Schools have an important role to play in preventing illness among students and the community, particularly by instilling good habits in their students which will last a lifetime” (Lee & Greig, 2010).

Vulnerable Populations

There are vulnerable populations that are more susceptible to TB outbreaks. It is estimated that there were 564,708 homeless people in the United States in 2015 with a large proportion living in shelters run by charities (U.S. Department of Housing and Urban Development, 2015). “San Francisco has the highest rate of tuberculosis (TB) in the U.S. with recurrent outbreaks among the homeless and marginally housed” (Higgs, Mohtashemi, Grinsdale, & Kawamura, 2007). A cross-sectional study was done to examine the adults in San Francisco who sleep in shelters or who eat in free lunch lines (Zolopa, et al., 1994). This study showed that poor social conditions such as overcrowding in shelters, lack of hygiene, and lack of access to medical care contributed to the spread of TB in this population. Until these issues were resolved, the authors felt TB outbreaks would be a problem in this population for some time.

Populations afflicted with substance abuse are also vulnerable to TB outbreaks. A report titled “Tuberculosis Outbreak Investigations in the United States, 2002–2008” focused heavily on substance abuse and its correlation with TB. First, people with substance abuse issues are more likely to develop TB due to their social lifestyle choices and be non-compliant with their treatments (Mitruka, Oeltmann, Ijaz, & Haddad, 2011). Second, those with substance abuse are more likely to delay seeking medical treatment, therefore increasing the time of their infectious period. Third, in a contact investigation they may not be willing to give the names of their contacts. In a separate study, the authors stated “Tuberculosis infection was extremely prevalent in the sub groups that live in shelters or crowded SRO(single room occupancy) hotels and in injection drug users” (Zolopa, et al., 1994).

However, the largest reason found for continued infectiousness in active TB cases was challenges in diagnosis by physicians. Tuberculosis cases can be missed because symptoms are similar to other more common diseases. This is especially true in countries where TB is not at the top of a differential diagnosis list. In the “Tuberculosis Outbreak Investigations in the United States, 2002–2008” report, there were 24 outbreaks with prolonged infectiousness, and of those 24 there were 7 outbreaks due to provider-related diagnostic delays (Mitruka, Oeltmann, Ijaz, & Haddad, 2011).

The first case was an outbreak of 19 active TB and 43 LTBI cases in a primary school in Italy (Filia, et al., 2011). The index case was a 42-year-old woman who had LTBI acquired from her husband and son and never completed her course of treatment. She was a teacher’s assistant in a kindergarten class in the primary school. She did see her family physician for a year prior to the start of the outbreak and was treated incorrectly with mucolytic and antimicrobial drugs. The authors remarked that particularly in their country, Italy, “This finding indicates the need for increasing awareness of TB among primary care

physicians and for improving their ability to recognize risk factors for infection and progression to active disease" (Filia, et al., 2011) If the index case's active TB had been identified at the initial medical screening at her family medical doctor, there perhaps would have been a more limited outbreak, because her infectious period would have been cut down by 11 months.

The second case was an outbreak in a Japanese high school which was limited and only infected 4 students as were confirmed by the QuantiFERON-Gold test (Higuchi, Harada, Nobuyuki, Mori, & Sekiya, 2007). However, the index case was infectious at least 9 months prior to his diagnosis of active TB in December 2002. In April 2002, he had a CXR in which his school doctor saw a cavity in the lung. The school doctor did reexamine the boy in July, and the cavity had grown, but there was no treatment given. The index case came back for 3 days after the summer vacation (August) and then was unable to attend school, because he was too ill. The student was even hospitalized in November, but TB was not diagnosed then. The index case saw 4 different physicians and was hospitalized twice before the diagnosis of TB was made. However, this outbreak was not as large as it could have been because the index case was too ill to attend school starting in August during his infectious period.

The third case was a 15-year student from rural Missouri who went to his family physician with upper respiratory symptoms and a cough (Phillips, Carlile, & Smith, 2004). He was diagnosed with pneumonia based on a CXR that showed an infiltrate and a lesion in his lung. For the next 6 months, the index case visited 10 more clinics throughout the region as his symptoms continued to get worse including weight loss, fever, and hemoptysis. He was referred to a pediatric hematologist who did a TST test and then referred him to a pediatric pulmonologist who confirmed the diagnosis. Overall there were 58 students of the 559 tested who had positive TST tests and needed to complete treatment.

Chapter 3: Notification

Detection

On November 8th, 2016, a 15-19-year-old high school student with active pulmonary TB was reported to the Douglas County Health Department (DCHD) by a pediatric infectious disease physician in Omaha, NE. When an active pulmonary TB case is reported to the DCHD an investigation is started in the communicable disease epidemiology section. First, this section has two public health nurses dedicated to TB specifically. When a lab, nurse, or physician calls into the health department, the TB nurse's first step is to see if the result they have received is sufficient, or if they need to proceed with specimen collection (C. Monk, personal communication, February 2017).

The communicable disease epidemiology section collects sputum specimens for multiple laboratory tests that will confirm the diagnosis. The DCHD interviews the index case to investigate where they may have gotten the TB from. Although they do not typically work through the physician's office, they do keep them informed of the results, and will work with them for treatment plans. (D. Simon-Smith, personal communication, February 2017).

Index Case

The index case in this contact investigation was a 15 to 19-year-old high school student. The index case had a history of a positive TST test in 2011, but only partially completed their treatment for LTBI. Prior to the November 8th diagnosis of LTBI, the index case did have a pre-existing medical condition that could have contributed to the activation of their LTBI. The index case has an autoimmune disorder was placed on a standard treatment of corticosteroids (K. Gundabolu, personal communication, February 2017). However, a side effect of the corticosteroid treatment is that is it lowers the immune system leaving the patient more susceptible to infections or reactivation of latent infections.

The index case was admitted to the hospital from November 4th to November 9th; and during this stay they tested positive for TB. The index case's AFB smears were graded at 0-1-0. When the index case was discharged from the hospital they did follow up with infectious disease outpatient to continue the management of this TB for the remainder of the 6-month treatment plan. They were also placed on directly observed therapy (DOT) protocols in which either a DCHD TB nurse or a school nurse watches the patient take their treatment Monday through Friday. This is a standard protocol for any active case, or for any latent TB case that is considered at risk for non-compliance (C. Monk, personal communication, January 2017)

First Steps at DCHD

There are several steps that the DCHD takes when notified of an active pulmonary TB case. The first step is to place the active patient in isolation. The index case was placed in isolation in a room within their home and instructed to use a surgical mask. The only people who entered the patients room were the index case's parents, who were also masked. However, DCHD staff wore N-95 masks, due to the extremely small particle size of the TB mycobacteria, when they were in the home during the index case's infectious period and while investigating contacts (D. Simon-Smith, personal communication, February 2017). The index case was educated that they would be placed in isolation until they had three negative sputum smears tested for AFB. The index case did have to remain out of school until they were deemed to be not communicable.

Another important step is the collection of samples from contacts. This is a relatively quick process, particularly if the tests come back negative. In this contact investigation, the index case was already inpatient, but the DCHD were utilized to gather samples from the familial exposed contacts (C. Monk, personal communication, February 2017). After a positive screening, a CXR is ordered, then sputum labs if the x-ray looks suspicious. The first test is the AFB smear

and culture. The smear is a test where the sputum is placed on a slide with a stain meant to highlight any AFB cells in the sputum to make them visible to a pathologist. It can be read within a few hours and can give preliminary results to physicians and public health officials on the presence of TB bacteria. There are typically 3 slides prepared to compare the number of AFB cells in each sample. In the index case, they had rare amount on the first slide (grade 1), none on the second slide (grade 0), rare on the third slide (grade 1). Sputum cultures take 6-8 weeks to grow, but are definitive results for drug susceptibility; whereas The AFB smear is a presumptive test. The smear and culture tests are specialized tests that are only able to be completed in specific labs, most cities have at least one that can complete these tests (J. Frederick, personal communication, January 2017). The second test to complete is the DNA Probe test which only takes a few hours to complete. In this index case's was positive.

Lab Results

There were two samples taken from the index case when they were an inpatient at a hospital in Omaha. The first sample was taken on November 6th and was sent to the facility's reference lab. Their results on November 25th indicated that the identified Mycobacterium was Pyrazinamide (PYZ) and Isoniazid (INH) resistant. These results typically indicate an infection by mycobacterium bovis instead of the initial diagnosis of mycobacterium tuberculosis (P. Iwen, personal communication, March 2017). While Mycobacterium bovis is uncommon in the United States or Nebraska, it has been seen formerly in Nebraska in 2014-2015 with an outbreak that showed 2 active TB cases and 45 latent cases (Buss, et al., 2016). The index case's antibiotic therapy was changed on November 29th to levofloxacin, rifampin, and ethambutol.

In addition to the sample taken on November 6th, there was a second sample taken on November 7th that was sent to an academic medical facility in Omaha, NE. The academic medical facility sent out the sample to their reference lab for more advanced testing. This reference lab

was a CDC reference lab and used a technique called pyrosequencing. Pyrosequencing is "a rapid real-time method for sequencing small segments of genomic DNA that has shown success in detecting mutations associated with drug resistance" (Lin, et al., 2014). This technique is more precise and was able to detect that the index case actually had two mycobacteria strains in their sputum whereas the technology the other reference lab was using could not. The index case had mycobacterium tuberculosis and mycobacterium arupense, which is an uncommon mycobacterium that was first identified in 2006 (Tsai, et al., 2008). This result showed that the index case was susceptible to Pyrazinamide (PYZ) and Isoniazid (INH), and so their treatment plan was changed again on December 15th (P. Iwen, personal communication, March 2017). The medication was changed to Isoniazid, Rifampin, and Pyrazinamide for 2 months and then after the higher-level dosing for 2 months, the index case would take Isoniazid and Rifampin for an additional 4 months.

Chapter 4: Epidemiological Response

Control

Once the index case had a confirmed diagnosis of *Mycobacterium tuberculosis*, the DCHD expands their contact investigation. The interviewing of contacts and expanding of treatment to contacts does not begin until an official diagnosis of TB is made. While the DCHD expands the contact investigation, they also continue to isolate the index case, if necessary until three negative sputum's are returned (J. Frederick, personal communication, February 2017). This process of smear testing sputum starts after 2 weeks of antibiotic treatment for cases. Active cases are not released from isolation until they have three negative smear tests, and if they come back positive, they must wait a week to test again. The index case was also still under directly observed therapy (DOT) per physician recommendations and will continue this for the length of their prescribed treatment plan which will continue to be managed by their pediatric infectious disease doctor (D. Simon-Smith, personal communication, February 2017).

Contact Investigation

The next step for the epidemiology team at DCHD was to start the process of determining close contacts. To determine the close contacts in a contact investigation, the CDC recommends going back 3 months before the first TB symptoms, or the first TB positive test, whichever is longer (Centers for Disease Control and Prevention, 2005). The two TB nurses at DCHD interviewed the index case and their immediate family and determined there were 17 close contacts who needed further testing. A contact investigation starts with the immediate household, and then may expand if transmission occurs. These questions will help determine if transmission has occurred. Some questions that they were asked to determine who some of these close contacts would include: Who lives in the home? Do any children live here? Does

anyone visit here every day/often? Do you have any close friends who aren't at your school (C. Monk, personal communication, January 2017)?

The household contacts identified in this contact investigation were seventeen household members and close friends of the index case. The first group of exposed contacts were people who were living in the house (the index case lived in a multi-generational, multi family home with 13 people). There were four extended members that were living in close proximity that visited the family almost every day (D. Simon-Smith, personal communication, February 2017). There were also some contacts identified at the hospital where the index case was an inpatient, but that hospital decided to do their own internal investigation, so DCHD no longer included them in their own contact investigation. Lastly, there were 4 close friends of the index case who attended the same high school that were identified as exposed contacts. However, it was decided they would be tested at the high school testing clinics.

After identifying the contacts was an interview with a TB nurse and interpreter (if necessary) asking questions. The index patient does speak English fluently, but due to the language barrier with the index case's parents, the TB nurses would use phone interpreters. The questions asked to close contacts are used to determine if any of the close contacts are symptomatic to rule out further active cases. The TB nurses perform a nurse's assessment and test each contact. Questions included: Do you currently have a fever? Have you had a prolonged cough? Have you lost any weight without trying (C. Monk, personal communication, January 2017)?

Thirteen of the contacts completed QuantiFERON tests and four had TST tests (the four were under the age of four). The children were given TST tests as there has been very few reports documenting the successes of the QuantiFERON test in children under the age of five (Qiagen, 2013). The children under four were immediately started on antibiotic prophylaxis as is

a standard protocol called “window period prophylaxis”. This is done as children are much more susceptible to infections such as TB. Children are placed on a prophylactic antibiotic for twelve weeks and a TST is repeated at the end of the twelve weeks. If the TST is negative, and the child is not exposed to any other potentially active cases, they can discontinue their treatment. (Heartland Tuberculosis Center, 2006). Of the four children who were started on the window period prophylaxis, two of the children who were relatives of the index case and not living in the household stopped after one week of the prophylaxis due to non-compliance by the parents. The other two children were living in the same house as the index case did complete 12 weeks of window period prophylaxis (D. Simon-Smith, personal communication, March 2017). This initial testing was done to identify the persons who already had LTBI and see if there would be conversions in 8-12 weeks when DCHD would retest to prepare those with TB for treatment.

Household Cases

Of the seventeen identified contacts three tested positive for LTBI in the first tests. Two household contacts and one close contact who lived down the street from the index case tested positive in the first round of testing. Age ranges for the positive contacts were 10-15, 70-75, and 30-35. Each of the contacts has been referred to a physician for CXR and treatment of LTBI (D. Simon-Smith, personal communication, March 2017).

On the second round of testing of the household contacts 11 weeks later, there were two converted cases. Two of the household contacts did have positive QuantiFERON tests when retested. Their age ranges were 45-50, and 70-75. Both of these conversions lived in the same home as the index case. One of the contacts had additional exposures to the index case during the index case’s infectious period as the contact did go into the index case’s room when they were in isolation, although the contact was masked. Both of these contacts also were referred

to a physician for CXR and treatment of LTBI (D. Simon-Smith, personal communication, March 2017).

While the immediate close contacts to the index case were being tested and were being treated, the investigators at DCHD also widened the scope to investigate other potentially exposed contacts. In addition to the index case's inpatient admission in November 2016, the index case was discovered to have ten other instances where they were a patient in other outpatient departments that may have exposed other patients at the medical facility. The facility has its own infection control department that was able to run its own contact investigation. Overall the infection control department identified 99 potentially exposed patients. The Director of Infection Control noted that to determine the exposed contacts the department considers anyone within 50 feet within an hour of the index case being in the area as potentially exposed. To date there are two LTBI identified through the investigation at the pediatric facility. One of the two had a history of travel of an area with endemic TB, but the other had no known risk factors and was considered infected by the index case. At the time this report was written, the hospital has not completed their second round of testing to identify any further converted cases.

The first meeting to discuss other potentially exposed contacts outside of the household was on November 15th at DCHD. This included those potentially exposed at the high school where the index case was a student. The meeting included a DCHD Medical Advisor and Pediatric Infectious Disease Specialist (Physician), DCHD's Senior Epidemiologist (Physician), the Supervisor of Communicable Diseases and Epidemiology (Epidemiologist), and the Division Chief of Health Data and Planning. The experts around this table met to discuss the scope of the contact investigation. First, it was decided to consult further expertise for school based contacts, this will be discussed later in this paper. Second, a separate contact investigation, it was

determined, would be held at the hospital where the index case was diagnosed with TB for any potential exposed contacts there.

Interaction with the School

On November 17th, a teleconference meeting was held with a medical expert from the Heartland National TB Center. It was determined that testing should be offered to all close, or classroom contacts of the index case (J. Frederick, personal communication, Jan 2017). This was determined as these contacts were at the highest risk of prolonged exposure to the index case. Additionally, the contact investigation could be expanded in the future, if the number of number of students who tested positive on the second round of testing was high (although there was not a threshold number in mind). At this time, the Health Director initiated the incident command system (ICS) for the school testing and the remainder of this response. ICS was initiated because of the scale of the contact investigation and the limited number of TB nurses that DCHD has.

This November 22nd meeting included the Supervisor of Communicable Disease and Epidemiology, Director of Health Services at the school district, the Principal of the high school affected, the Director of District Communications, DCHD's Senior Epidemiologist, English as a Second Language Coordinator, and the Assistant Superintendent. At this meeting the administration was briefed about the index case's medical condition, how long their infectious period was thought to be, and how the high school was to identify the close contacts are (classroom contacts, not just anyone walking in the hallway) (J. Frederick, personal communication, February 2017). Additionally, discussions at this meeting regarding the unique student population of the high school arose, and that special considerations would need to be made regarding translating letters when sending them to families. The high school is incredibly diverse with 74% total minority population and 81% of the students eligible for free or reduced

price lunches due to economic disadvantages (US News, 2017). The high school also has the highest rate of refugee students at a high school in the school district at 18.6% (Omaha Public Schools, 2016).

During the meeting a plan for the timing of the blood testing clinic and communications rollout was developed. The following dates were established: November 28th the school district would send letters (translated into 5 different languages for those who would require it) to the entire student body (exposed/non-exposed students would receive two separate letters) regarding a case of active TB in the school. November 30th there would be a "Robo-Call" or an automated calling system to remind families to check their mail, and of an upcoming parent meeting on December 1st. November 30th 2:30 PM faculty education for exposed faculty; faculty education for non-exposed faculty. December 1st there would be an open parent meeting at 6:30 PM for parents of exposed and non-exposed students. The testing of students and faculty would occur on December 6th and 7th (7:40 AM – 2:30 PM) and morning clinics on December 8th and 9th (8:00 AM – 12:00 PM) (T. Morrow, personal communication, February 2017).

With the conclusion of the meeting with the administration at the school district, this contact investigation became a much larger response. The testing of 196 identified contacts and the formation of 2 testing clinics in a high school gymnasium over the course of 3 months. The next section of this thesis will focus on the clinical response and the different challenges that were overcome to ensure that 92.3% of the original 196 identified contacts were tested at least once.

Chapter 5: Public Health Response

Communications

Communication was an integral part of this contact investigation's clinical response. DCHD's Public Information Officer (PIO) worked with the Director of District Communications to ensure that messages from DCHD were sent through channels familiar to district families. The first communication challenge came after the first notification letter was sent to the student's homes. One parent posted the letter on social media which led to multiple phone calls to both the school and to DCHD from other families who had not yet received the letter, and from the local media. In response to this event, the DCHD Health Director and Senior Epidemiologist held a press conference within 90 minutes of the first phone call. The press conference was well received by parents and the community (P. Rooney, personal communication, March 2017).

There was also some national media attention focused around the first clinic. In particular, from an online news source, that focused on the diversity and the number of refugees of the High School involved in the contact investigation (Leahy, 2016). This media piece was the only one to garner national coverage and occurred due to the political climate at the time that was critical of refugees and immigrants. The PIO posted clinical information about active vs. latent TB, when the clinics were scheduled, and the number of students and faculty who tested positive for LTBI on social media (twitter, Facebook) to keep the public at large informed about the progress of the health department (P. Rooney, personal communication, March 2017).

One technical glitch in communications that occurred was with the Health Alert Network (HAN) information meant to notify providers about the active TB case and signs and symptoms to look for in their patient populations. The HAN is an email and fax system hosted by the Nebraska Department of Health and Human Services that are used to communicate with

public health partners. The HAN for the first clinic was sent out on November 30th and was successful via email and posting via the website, but failed via fax. It was reattempted, but failed again. The HAN via email and posting on the DCHD website reaches most of the healthcare providers.

Separate educational sessions were held for the school faculty and the parents. The session for parents was poorly attended, given the number of students at the school. The DCHD medical advisor and pediatric infectious disease specialist answered questions regarding TB and its transmission. While the Supervisor, Communicable Diseases, Epidemiology answered questions regarding public health response, the clinics, and the testing of their children. There were also fact sheets available for the parents to take home and review. Internal communications strategies at DCHD included an email to all staff immediately following any news releases, in an effort to ensure that everyone was informed. This strategy eventually evolved to include an email to staff immediately prior to the news release as the news cycles were slowing down and time allowed for that change (P. Rooney, personal communication, March 2017). This change was integral to ensuring staff was informed while out in the field serving the community.

First Clinic

Early in the planning stages it was decided that a modified Point of Dispensing (POD) clinic would be the best way to get the students and faculty tested through in an efficient and effective manner. DCHD participates in CDC's program called the Cities Readiness Initiative (CRI). CRI is defined as "a federally funded program designed to enhance preparedness in the nation's largest population centers. This where nearly 60% of the population resides and is designed to effectively respond to large-scale public health emergencies needing life-saving medications and medical supplies" (Centers for Disease Control and Prevention, 2016). Medical Countermeasures

(MCM) can include biologic products such as vaccines, antivirals, and personal protective equipment (PPE). These MCM are dispensed via PODs that are scalable, meaning they can be expanded for large incidents or contracted for small incidents.

They also include the Incident Command System (ICS) and this structure is personally familiar to those working in the DCHD as they have exercised POD clinic structure many times. ICS is defined as "The Incident Command System (ICS) is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure" (Federal Emergency Management Agency, 2016). During this response, the DCHD operated under operational periods to denote planning periods and to follow the incident command process. These operational periods are defined as the period of time the team has to execute the actions defined in the Incident Action Plan (Federal Emergency Management Agency, 2016). For this response, the operational periods were typically a week long, but did vary based on the activities required at the time (T. Morrow, personal communication, February 2017).

The first clinic was held from December 6th – December 9th. Setup of the clinic occurred the night before the clinic. The logistics chief's, planning chief, operations chief, and public information officer oversaw the setup of the clinic (T. Morrow, personal communication, Jan 2017). When staff/volunteers reported to their shift they would receive just in time training (JITT), and then report to their stations. JITT is essential to clinical operations as plans include using staff who don't usually work in these settings, and this training gives them guidance on their duties and the operational goals of the undertaking. Some stations included registration, blood draw assistant, greeter, wrangler, etc. Students walked into the gym with their respective classes, checked in with the greeter. Then report to the registration table who would check over

their consent form, give them a set of labels, and then send them to a set of chairs to wait until someone was ready to draw their blood.

The wranglers would then make sure the students waiting in the chairs were calm and would escort them back to the draw stations when one was ready. The assistants and draw stations would draw the blood and ensure the specimens were handled correctly. Once a student had completed the blood draw, if they needed a few minutes (if they were light headed) there was an observation area they could go and wait. Otherwise, they would be directed to a group of chairs to wait with the students of the class who had already finished until everyone else was done.

For the first clinic, it was determined there would be 5 blood drawing stations for the 4 days of the clinic. These would be manned by 2 public health nurses (from DCHD), a state TB coordinator RN, an additional RN the state of NE provided, an EIS officer from the CDC, and lastly a phlebotomist for challenging venipunctures. Whole classes came to the clinic and processed through as a group of approximately 30 students. Volunteers were utilized and the Student Response Team (SRT) at the University of Nebraska Medical Center (UNMC) was contacted and the Student Response Team Faculty Coordinator committed 23 SRT members for the 4 days of the clinic for various shifts (T. Morrow, personal communication, Jan 2017).

Clinic supplies were handled by the logistics chief in coordination with the clinic section chief. Most of the supplies were already stored in the DCHD warehouse. Any additional specialty clinic supplies that were needed were ordered by the clinic section chief. The logistics chief worked with the high school to set up delivery and storage of the clinic supplies and equipment in a secure area the day before the testing.

Evaluation of First Clinic

A number of hot washes were conducted at the end of the first clinic to determine if the operational procedures were successful and those that needed improvement. A hot wash is the evaluation of the operation immediately following an operation. There was a hot wash at the clinic site, there was a hot wash held by DCHD leadership that conducted an internal review of clinic operations from a strategic vantage point, and evaluations filled out by clinic staff about operations.

Things that Went Well

- Clinic flow was well organized
- Staffing was adequate
- Following the modified POD plan was successful
- Smooth public information rollout
- Parent/teacher meetings were informative
- Good use of colored vests to identify clinic vests
- Good use of Student Response Team for external volunteers

(T. Morrow, personal communication, March 2017).

Areas of Improvement

- Flow of students from classrooms to the clinic
- Absence of signed consent forms
- More emotional students were harder to draw and slowed down clinic operations
- Food supplies were stolen from locked storage area
- Completing demobilization each night was time consuming
- There needs to be more training on staying in the area of assignment and the use of flags instead

(T. Morrow, personal communication, March 2017).

Second Clinic

Planning for the second clinic began in late January with an initial meeting with the principal of the high school and the operations section chief to discuss any potential changes that would be made to the clinic flow. The need for two clinics was again due to having to wait eight-twelve weeks for an immune response to the mycobacterium in the student's body. Changes made to the clinic operations included: shortening the clinic to two full days of clinic testing, and only have three drawing stations instead of five. A change in the process for bringing students from class to the clinic was proposed, since the composition of classes had

changed from fall to spring semesters. School leadership issued twenty passes per ninety-minute period to student contacts. This regulated the flow of students into the clinic setting. Faculty was tested at any point in the day.

In the weeks leading up to the clinics planning meetings resumed with the following people: both logistics chiefs, the planning section chief, the operations section chief, clinic section chief, safety officer, public information officer, incident commander, and deputy incident commander/liaison officer. Other changes to the clinic operations process included a revised letter to parents emphasizing the importance of a second test. This letter was sent by e-mail and a communication was issued using a reverse calling system (robo-call technology). School nurses were also enlisted to assist with obtaining the signed consents at upcoming parent-teacher conferences

Clinic staffing needs were filled with internal DCHD employees for eight hour shifts instead of using external volunteers. This was intended for DCHD staff to gain experience and to eliminate the need for JITT for volunteers at each shift. Storage locations for both food and medical supplies were changed to ensure safety, security and decrease the chances of theft.

Three positions were added to the ICS structure to help with the clinic flow. A registration area runner, a blood draw area runner, and a supply manager. The “runner” position was added to the clinic intake area to restock any additional food and supplies that were needed. Another “runner” position was added to the blood draw area and was used to help bring medical supplies from a newly placed supply table to the blood draw stations as needed. This person also guided students to the exit table to get a hall pass and/or direct students to an observation area if necessary. The final position to be added was a supply manager to operate a supply table with medical and non-medical supplies and periodically take inventory of supplies.

The second clinic was held from February 21st – 22nd. The flow of the clinic was similar to the flow of the first clinic with the addition of the three positions mentioned previously and an exit table where students were given hall passes to return to classes. The three draw stations were manned by two DCHD TB nurses and one phlebotomist from the Nebraska Public Health Laboratory. Eighty-eight faculty and students were tested on the first day and fifty-five were tested on the second day. A DCHD TB nurse returned a third day to draw specimens from the remaining sixteen faculty and students who were on a field trip the previous day.

Evaluation of Second Clinic

Again, there were a number of hot washes and evaluations held after the second clinic to appraise clinic operations. In addition, the hot washes held after this second clinic evaluated the process of planning and operations since the notification stage.

Things that went well

- Good teamwork amongst those working
- Helpful signage
- Good use of flags to summon assistance
- Having a dedicated person to manage the supply list was useful
- Having longer 8 hours shifts made clinic run smoother
- Locking up of the supplies improved
- School nurse cooperation was integral
- Having a setup team was helpful

(T. Morrow, personal communication, March 2017).

Areas of Improvement

- There needs to be a way to confirm the parent's declining a blood draw
- Students not returning consent forms still a major challenge
- better separate area for those who needed to be tested vs. those who have already been tested
- high noise level in gym (perhaps get a mini-vox?)

(T. Morrow, personal communication, March 2017).

Chapter 6: Results

First Clinic

High School TB Clinic, Round 1
N = 196

	Staff (n = 17 total)	Student (n = 179)	Total	Percent
Positive	1	6	7	3.6%
Negative	16	150	166	84.7%
Indeterminate	0	0	0	0.0%
MD	0	0	0	0.0%
Total Tested	**17**	**156**	**173**	**88.3%**
Not Tested	0	23	23	11.7%

Table 1

During the first clinic, there were one hundred and ninety-six contacts identified. There were one hundred and seventy-three of those contacts identified tested, and seven that tested positive for LTBI. These seven positives included one faculty member and six students. After the clinic, the epidemiology team at DCHD did some investigation on each of these positives and found other possible risk factors for each of the positives except one. These risk factors include history of LTBI, family history of LTBI, immigrant status, etc. What this means, is that it is probable these positives did not get TB from the index case. It is not possible to know that for sure for the one latent positive who did not have other risk factors.

Those twenty-three students who were not tested at the first clinic did receive follow up phone calls and letters from the DCHD reminding them of the importance of getting tested. Six of the students did end up coming to get tested in the second round of testing, but fifteen did not ever come in to get tested despite numerous attempts to get them tested at the school and offers to let them be tested at their convince at the DCHD clinic or at their own physician.

Demographics for the students who tested positive at the first clinic included one faculty member and six students, Each of the latent cases identified at the High School were recommended to be treated with a four-month treatment of Rifampin.

Second Clinic

High School TB Clinic, Round 2
N = 189

	Staff (n = 16 total)	Student (n = 173)	Total	Percent
Positive	0	1	1	0.5%
Negative	13	144	157	83.1%
Indeterminate	0	1	1	0.5%
MD	1	3	4	2.1%
Total Tested	**14**	**149**	**163**	**86.2%**
Not Tested	2	24	26	13.8%

Table 2

During the second clinic, there were one hundred and eighty-nine contacts identified that were to be tested (the original one hundred and ninety-six minus the seven positives removed from the first clinic who did not need to be tested a second time). Over the course of two days (plus returning for the half day in the school nurse's office), there were one hundred and sixty-three faculty and students tested with one student conversion to a positive QuantiFERON test. Since the student tested negative in December, and positive this round of testing, it is highly likely this was due to the exposure to this index case. There were no other risk factors identified for this student based on investigation by DCHD epidemiologists.

During the second clinic, there were also a few faculty and students who were not tested for various reasons. First one faculty member and three students reported they would be going to their own physicians for second round testing. Second, there was one faculty member and twenty-four students who chose to not get tested during the second round. There was also one faculty member who was no longer a faculty member at the school who also chose to not get tested. There was also one student whose results came back as indeterminate, and was notified they would have to come to DCHD for further testing, and they did not return for testing. This latent case was treated just as the others with a four-month treatment of Rifampin.

High School TB Clinic Overall Results

N = 196

	Total	Percent
1st Clinic Only Positive	7	3.6%
2nd Clinic Positive (Converted)	1	0.5%
2nd Clinic Indeterminate	1	0.5%
1st Clinic Only Negative	16	8.2%
2nd Clinic Only Negative	6	3.1%
1st and 2nd Clinic Negative	147	75.0%
Private Physician	3	1.5%
Never Tested	15	7.7%
Total	196	100.0%

Table 3

Chapter 7: Discussion

The DCHD conducted a contact investigation and tested two hundred and thirteen contacts of the index case, and one hundred and ninety-six of them at the High School the index case attended over the course of four months (November 2016 – February 2017). This contact investigation ensured collaboration amongst many departments within the DCHD including epidemiology, emergency response, administration, public information, and clinic operations. This amount of coordination would have been difficult without the use of the modified POD and the ICS structure that was used. The ICS structure that was taken out of that POD plan and modified for this organization was key to make sure every aspect from clinic operations to finances was taken care of while the students and faculty were taken care of in an effective and efficient manner.

ICS is routinely used by emergency responders such as firefighters and police, however it can also be useful for public health emergency response. It is important to note that in this contact investigation there were some necessary changes to the typical ICS structure. Operational periods were often over twenty-four hours due to the length of this response, titles may have been changed to more accurately reflect clinical responsibilities, etc. It is vital in Public Health preparedness response to modify the ICS structure to fit the needs of your organization, while also maintaining important key details such as span of control and establishing the five key command positions: incident commander, operations section chief, planning section chief, logistics section chief, and finance section chief.

Another key accomplishment during this contact investigation was the ability and foresight of the administration to make major changes to the clinic structure between the first clinic testing and the second clinic testing. While the first clinic testing was effective it was quite a bit longer and tested fewer faculty and students each day. The operations chief saw the ability

of those working the clinic to see more faculty and students each hour and proposed the change to two full days with twenty students per hour as to have a more consistent flow. This cut down on lag times, meant fewer days DCHD staff had to be away from their regular duties, and fewer days this would disrupt the school's normal routine. Also, adding three new positions of two new runners and a supply manager made the days run much smoother and those at higher clinic administration positions did not feel weighed down by menial tasks. The changes made between the two clinics were integral in making the second clinic run as smoothly as it did.

There was also an especially low infection transmission rate in the school. While there were seven initial positives during the baseline round of testing the epidemiologists at DCHD were able to find other risk factors for almost all seven of those positives, and therefore they may not have been linked to the index case. During the second round of testing there was only one person who converted, or only one person who testing positive the second time when they tested negative the first time. In this case, there were no other risk factors that could have contributed to this student having converted to a latent TB test, therefore it is linked to the index case. However, out of testing one hundred and ninety-two classroom contacts at the school and having only one conversion, that is a conversion rate of 0.5%.

This rate is not surprising due to the index case's AFB smear grade being so low. Studies show that the higher the AFB smear grade, the higher the relative risk for transmission of TB to other people (Lohmann, et al., 2012). Also, the school is a large building with a large ventilation system. In addition, the index case is further apart from the students in school than the index case may be from their family members at home. Household contacts of active TB cases are particularly susceptible to contracting TB from the index cases they live with. The study remarked "The incidence of active TB among adult household contacts of sputum smear-positive PTB cases was high. This high incidence justifies the prescription of chemopropylaxis not

only for children but also for all contacts, especially those aged between 15 and 34 years" (Kilicaslan, et al., 2009).

There were originally 17 contacts in the index case's family, three tested positive on the baseline round so were most likely not infected by the index case. On the second round of testing there were two conversions, so a conversion rate of 14.3%. This could be due to several factors including closer quarters in the home, poorer ventilation than the school, etc. Family members are also often more affectionate and closer in physical distance with one another than one would be in a school setting. These factors would contribute to the transmission of TB from an active patient.

There were some limitations during this contact investigation. First, were the consents that the students had to return before they could get their blood drawn. With the legal language on the consents, there needed to be one consent signed by a guardian of the student before each of the clinics and that proved to be difficult to obtain. This could be due to a number of circumstances including the students not giving the forms to the parents or guardians, the students not returning the forms, the parents not understanding the importance of getting tested twice, etc. It was suggested in one of the clinic hot washes that in the future perhaps the legal department could look into changing the language so that one consent form could cover both blood draws with one parent or guardian signature. This could potentially save quite a bit of work for the school nurse who had to get verbal consents for any student who did not have a signed consent form (of which there were many).

A last limitation that was encountered in this contact investigation was the population served in this high school. As was discussed earlier, it has a large refugee population that may have different medical practices in their countries of origin and are wary of traditional western medical practices.

Conclusion

In conclusion, this was a successful contact investigation operated in an urban high school in Omaha, Nebraska. This diverse school tested the Douglas County Health Department in its emergency response planning and epidemiology capabilities and the DCHD responded effectively and efficiently. Everyone who has been identified as positive is either being treated or in the process of getting set up for treatment and this will minimize the risk of new case of active tuberculosis. The coordination and communication both within the agency and with other organizations throughout the city have shown that a successful contact investigation can be run using a modified POD structure and ICS principles.

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