
An Epidemiological Link Study of High School Pulmonary Tuberculosis Cases in Hualien County

Chi-Fang Feng¹, Chun-Ting Chan², Bei-Chin Huang¹, Chin-Fen Ko¹,

Chien-Jung Hung¹, Yi-Chun Wu³, Jen-Jyh Lee⁴, Jen-Shing Shih⁵, Yeong-Sheng Lee¹

¹Sixth Branch, CDC, Taiwan; ²Department of Public Health, Tzu Chi University;

³Third Division, CDC, Taiwan; ⁴Chest Section, Department of Internal Medicine,

Buddhist Tzu Chi General Hospital; ⁵Hualien County Health Bureau

Correspondence Author: Yeong-Sheng Lee

Abstract

The objective of this study was to probe the epidemiological link among students with pulmonary tuberculosis (TB) attending High School A in Hualien County and their link with student cases at two other schools in the same county, Vocational High School B and High School C. We made use of a Taiwan Center for Disease Control (CDC) tuberculosis reporting and managing system database, a semi-structured questionnaire designed by ourselves, along with interview sessions, to obtain demographic data on the TB cases, their individual living environments and habits, activity histories, contact histories, and disease histories. In addition, we conducted an on-site investigation at the three schools. In this

particular study, our findings revealed that almost all of the TB cases under our investigation were aboriginals and they did not have any apparent close contacts in the school environment. Instead, most of them seemed to have acquired the disease from their own family members. Our assumption that their disease might be part of a school setting related scenario is simply not true. This result indicates that the mechanism of TB spread among students in Hualien County is quite complicated and still beyond our total comprehension. Based on our findings, we suggest that in the future we should place more emphasis on keeping track of the family members of TB new cases among students, especially when the new case happens to belong to the aboriginals' group.

Keywords: pulmonary tuberculosis, epidemiological link, aboriginals

Foreword

Tuberculosis (TB) is a chronic infectious disease caused by bacteria called *Mycobacterium tuberculosis* and mainly spread airborne by aerosolized droplets. TB bacteria are aerobic in nature and can attack any part of the human body, but in more than 90% of the cases, they invade the lungs [1]. It is estimated that approximately one out of every three living persons worldwide were infected with TB. According to a 1990 survey, among the eight million newly acquired patients of TB globally in that year, five million come from Asia alone [2,3]. Another study published in 1995 also showed that the overall global average annual incidence rate of TB was 54.37 cases per 100,000 population [4]. Also in that particular year, a total of 17 million people were killed by communicable diseases worldwide, and of the total more than 3 million deaths resulted from TB. Another epidemiological data shows there has been a trend of a continuous increase in the TB incidence rate since 1958, which is thought to be largely owing

to the prevalence of Human Immunodeficiency Virus (HIV) infection [5].

In Taiwan, TB is a serious public health problem. The World Health Organization (WHO) has suggested a set of targets for TB control efforts to aim for: 1) an annual TB fatality rate of less than 2 cases per 100,000 population, 2) an adult prevalence rate of less than 0.14%, and 3) a child infection rate of less than 1% [6]. Compared to that guideline, the eighth survey of TB prevalence rate in Taiwan carried out in 1982 indicated that the rate reached 0.65% that year [7], and a more recent study revealed the 2003 death rate due to TB was 5.80 cases per 100,000 population [8]. Apparently, what has been accomplished by Taiwan's past TB control endeavors still lags a good distance behind the WHO standard. Furthermore, if we look into the situation in some local administrative regions, we find that the county most devastated by TB, Taitung County, has a frightening annual TB death rate of 16.84 cases per 100,000 population. Another eastern Taiwan county, Hualien, is currently number 3 on the list with a death rate at 10.81 cases per 100,000 population [8]. Therefore, TB is definitely still a significant public health problem especially in the eastern part of Taiwan.

Most previous studies published in Taiwan on TB mainly focused on its clinical medical, therapeutic or basic biomedical aspects. The very few TB studies in the interest of public health were merely discussions about TB control policy or reports of various survey findings, and almost no papers ever dedicated to an epidemiological link study of the disease were available. However, we felt that if we could obtain some relevant factual disease control experiences in specific epidemic situations, organize the data and familiarize ourselves with the spreading mechanism of infection sources, it would facilitate the process of control efforts in the future. Incidentally, there were two confirmed outbreaks of cluster TB infections in 2003; one took place at a hospital in Taipei City and the

other at a vocational high school somewhere in southern Taiwan. In order to better understand what might have gone wrong and hopefully be able to improve the on-going TB prevention program, or even develop some new and more effective prevention measures fit for hospitals and school surroundings in particular, the Taiwan CDC launched a special program of TB chest X-ray screening as a response, carried out in four randomly sampled sites of the northern, central, southern, and eastern regions respectively [9]. In the eastern region of the island, the Sixth Branch of the Taiwan CDC implemented the program in February 2004 by first randomly selecting Vocational High School B (VHS-B), followed by a chest X-ray checkup screening of all teachers, staff, and students of that school by the local health station. While performing the follow-up case contact examinations, we discovered one contact of a confirmed TB case attending High School A (HS-A) in the neighborhood, and HS-A happened to be the location where a probable cluster TB infection took place in late 2003. Besides, two weeks after the VHS-B chest X-ray screening event, another high school nearby, or High School C (HS-C), reported a smear positive student TB case. Tracing back the student's past activities revealed that this particular student was a recent transfer student from HS-A as well.

On the surface, each of the above-mentioned three events seemed to have been independent because they each occurred at a separate school environment. However, the epidemiological investigation unexpectedly disclosed the fact that some of the TB cases of these three schools were found and reported at times very close to one another. Further tracing back the history of such cases' activities and their close contacts indicated that they all seemed to have something to do with HS-A. This made us start to suspect that these cases might all be related and most likely a certain infection source might have been hidden at HS-A.

Therefore, we decided to first sort out the epidemiological link among the student TB cases within HS-A alone. We assumed a scenario that those cases had a common infection source related to HS-A, and this relationship involved certain shared environmental factors or activities, such as TB cases attending certain classes together and engaging in some extracurricular group activities.

Materials and methods

In this study we employed a retrospective descriptive research design, i.e. we chose all student TB cases attending HS-A, VHS-B, and HS-C reported in the period from October 2003 to March 2004 and their contacts as the principal subjects of our investigation. Originally, we had identified 12 original student TB cases and contacts, as well as 14 non-student contacts. However, we later lost track of one student case, and two student contacts and one non-student contact were further diagnosed to not be suffering from the disease. Therefore, we ended up with 9 students as TB cases and contacts, as well as 13 non-student contacts for our study.

Information about the research subjects that included their demographic data, living environments and habits, disease histories, activity histories, and contact histories was collected with the help of a Taiwan CDC TB reporting and managing system database, and a specially designed semi-structured questionnaire incorporated with face-to-face interview sessions. In order to ascertain the environmental influences, we personally visited the three schools to conduct an on-site investigation, to better understand the relative geographic locations where they carried out their daily routines and search for possible environmental risk factors.

Results

I. High School A

Hw-1, an 18-year-old aboriginal student of High School A (HS-A) in its Class A-1, went to see a doctor on December 22, 2003 because he had a persistent fever. As his TB sputum smear examination gave positive results, he was diagnosed and reported two days later as a new TB case. After the incident and beginning January 9, 2004, all 46 classmates of Hw-1 underwent the required contact chest X-ray checkups, and among them, Li-2 and Hu-3 were spotted and listed as probable cases as a result of the follow-up event. Later, Li-2 was diagnosed to not be suffering from TB and so his name was removed from the case list. However, Hu-3's sputum smear test turned out to be clearly positive. Because of this result the chest X-ray screening was expanded to include all students belonging to two other classes situated on the same floor of Class A-1, i.e. Class A-4 and Class A-5. But this extra effort did not result in finding any further TB cases (Table 1).

A. Hw-1 lives at home with six other family members. Except for Hw-1's father, Hw-18, the rest were proven disease free since their chest X-ray checkups were all negative for TB. Hw-18 was found and reported as an active TB case on April 3, 2003. Since his compliance with taking medicine wasn't ideal, he did not complete the necessary treatment until May 26, 2004. Another piece of information provided by a public health nurse working in the neighborhood was that Hw-1 had another relative living close by and registered as an under-special-care TB patient, who was also reputed to be not very compliant with taking medicine. Hw-1 seldom mingled with his neighbors. After school, Hw-1 would take part in some activities held by an aboriginals dancing club, or occasionally play ball with his classmate Hu-3.

From what we know about him, we suspect the source of Hw-1's infection could be either his father Hw-18 or his schoolmate Hu-3.

B. Among Hu-3's seven household family members, only his mother Ka-19 had an abnormal result on the chest X-ray checkup. Ka-19 was then reported as an active TB case on September 9, 2002 and had been under treatment ever since. The reason she could not complete the treatment sooner is that her TB bacteria had developed some drug resistance against Isoniazid (INH). Through searching in the Taiwan CDC TB reporting and managing system database, we also found that Hu-3's maternal grandfather, Ka-20, used to be a reported case back in 1985 and successfully completed the treatment regimen many years ago. Hu-3 had little contact with all his neighbors. At school, his favorite pastimes were playing chess and learning judo and he was an active member of two such student clubs. On other occasions he enjoyed playing ball or going swimming in a local stream with Hw-1 and some other schoolmates. We believe his infection probably came from his mother Ka-19 or his schoolmate Hw-1.

II. Vocational High School B

From February 9 to 12, 2004, the local health authority proceeded with a large chest X-ray screening event covering everybody associated with Vocational High School B (VHS-B), i.e. school administrators, teachers, clerks, students, and even voluntary workers. The total was supposed to be 1628, but 58 failed to participate because of staff taking those days off, students skipping classes, leave of absence due to death in the family, temporary dropout, etc. The preliminary findings of this mass screening indicated that seven students were probable TB cases. They were Dn-4, Ch-5, Cu-6, Yu-7, Cn-8, Cn-9 and Jo-10, and only Cu-6 was not aboriginal. However, the follow-up examinations confirmed three of

them being new TB cases, two being old cases, and the remaining two turned out not to be infected by TB bacteria at all (Table 1).

- A. On February 16, 2004, Dn-4 duly sent in a sputum sample for examination after he was found to be a probable TB case. The sputum culture turned out to be TB positive. He lived with 5 family members, but their chest X-ray checkups were all normal. As for the neighborhood contacts, we found out that Dn-4 had two cousins, Dn-11 and Dn-12, living next door who had been reported as TB cases before. Dn-4 spent most of his school hours in his classroom or on the drill ground, besides sometimes taking part in Boy Scout activities. After school he often went directly home. Occasionally he would play ball with friends or his cousin Dn-11. In that school-wide TB chest X-ray screening event, none of his classmates turned out to be TB positive, plus there was no sign that Dn-4 had ever had close contact with other TB sufferers in the school. Therefore, it is possible that he got the disease through his cousin Dn-11.
- B. Dn-11's TB status was discovered when he was urged to take chest X-ray screening as one of Dn-4's contacts. He was reported as an active TB case on February 28, 2004. His brother Dn-12 was reported as a TB case too, back on March 11, 1999. Due to poor compliance with taking drugs during the treatment, he had to prolong the treatment before completion. The remaining four household family members passed the chest X-ray checkup showing no abnormalities. Their closest neighbors were mostly relatives, and they visited one another very often. Dn-11 was a student of Class A-2 in HS-A. When all other students of that class took the required chest X-ray checkup for contacts, there were no other individuals with positive results found. On school days, other than attending classes regularly, Dn-11 engaged in some

extracurricular activities of a baking club and a guitar club between classes. On weekends and holidays, he liked to play ball with his relatives and friends, and participate in activities held by the church. From what we know, it seems possible that he got TB from his brother Dn-12 or cousin Dn-4.

C. Ch-5 was reported on October 14, 2003 as a new TB case. She told us during a visit we paid to her at home that when the summer vacation of 2003 was about to end, she started to feel not quite herself and coughed profusely. Shortly after in October, she went to hospital see a doctor due to haemoptysis (coughing up blood) and that was how she got spotted. In her household she has a father, mother and one younger brother, and all three had no signs of TB on the chest X-ray checkup that followed. However, an uncle on her mother side, Ch-13 was a reported TB case since April 23, 1997, and he visited the family on a regular basis. Since Ch-5 seldom chatted or did things together with her neighbors, the chance of getting infected from them was not very likely. Besides, Ch-5 lived in the dormitory during school days, and she stayed in her room most of the time except for attending classes and her favorite band activities. The entire school TB chest X-ray checkup results showed that none of the other TB cases in different classes, clubs, or dormitory residents ever had close contact with her. Therefore, Ch-5 was most likely infected through her uncle Ch-13.

D. Cu-6 was found to be an inactive TB case on February 16, 2004 during the school wide chest X-ray screening. Cu-6 lives mainly with her mother, whose TB chest X-ray checkup turned out to be clean. Cu-6 helps her mother to run a betel nut-retailing stand during the daytime and goes to school in the evening. Since they had just moved to Hualien City not long ago, she hardly knew her neighbors and seldom got into conversation with them. Cu-6

smokes, so during class breaks or recessions, she often went hiding in the washroom or some staircase corner to have a cigarette. Only occasionally she would chat with her classmates in the classroom or hallway. She often went home right after school hours, and only on rare occasions did she go out with friends to have fun. All her friends showed no abnormalities on their chest X-ray checkups. Since she was new in her current Hualien City neighborhood and she told us that she once lived with a junior high school classmate, Ch-14, for a short period of one month back in 1995, we suspect that Cu-6 might have been already infected then.

E. Yu-7 was found positive on her February 17, 2004 chest X-ray checkup and also positive in the following sputum examination by sputum culture. She lives with her daughter, whose chest X-ray showed nothing abnormal. Yu-7 sometimes would have a lengthy chat with her neighbors, but as far as we understand, there are no other TB cases known in that particular neighborhood. Since she went to night school, her activities at school were restricted to the classroom. From this school-wide chest X-ray screening, we also discovered in her class one more reported inactive TB case, Cu-6. However, their seats were not close and the two seldom spoke to each other before. Besides, being an inactive case, Cu-6 was not likely a disease spreader. During an interview, Yu-7 told us that about one year before, she frequently went to sing Karaoke with friends at a small and not well-ventilated room. She also revealed to us that she had once worked at a textile factory with her sister Yu-15, who was suffering from TB. Yu-15 was found ill and reported as a TB case in 1991. Two years later she completed the therapeutic treatment regime. Therefore, we figured the source of Yu-7's infection might have come from contact with either her sister Yu-15 or someone in her singing group.

- F. Cn-8 went to see a doctor and was identified and reported on October 14, 2003 as a TB case. Later when we visited her at home, she told us she felt unwell for a week or so before she went to see the doctor. She had a large family with 9 members and 7 of them were TB sufferers. Her father Cn-22 was the first one displaying TB symptoms and also reported as a TB case in the family and that happened on April 7, 1986. The others followed suit one by one and all completed therapeutic treatment regimes, except her sister Cn-26, who was reported on February 10, 2004 and is still undergoing treatment at the moment. Cn-8 likes to chat with neighbors but there are no TB cases in the neighborhood that we knew of. Since Cn-8 did not live in the dormitory, nor did she join any social clubs, her routine activities on campus were restricted pretty much to the classroom. She was a quite shy person, and even in the gym during PE classes, she interacted with nobody but her own classmates. After school hours she normally went directly home, without engaging in any other activities. From all the evidence that we could discover from the school-wide TB chest X-ray checkup results, she had not had contact with any TB cases at her school that we were aware of. The only exception was when she was hospitalized in isolation ward that she had close contact with Ch-5. Therefore, the source of Cn-8's infection is probably her own family.
- G. Jo-10 was diagnosed and reported as a TB case on August 9, 2001 and duly completed the required treatment. However, on the February 2004 chest X-ray checkup her findings had worsened and so she was registered again in the TB reporting and managing system database. Her family members and other contacts of hers passed the chest X-ray checkups with no problems, and she underwent one more round of treatment and apparently did well. Two months later she was given a clean bill of health on her checkup and the

diagnosed was changed to be not a TB case.

III. High School C

Sn-16, a 17-year-old, female aboriginal student of High School C (HS-C), Class C-1, all of a sudden coughed up a lot of blood on March 1, 2004 in a school washroom. Her class Teacher-in-charge notified the student's mother and sent the student to a local hospital. The chest X-ray taken on that day showed cavities in her lungs. The sputum smear test carried out the next day was proven positive. Because of the alarming outcome, all other 19 students in Class C-1 had chest X-ray checkups also on that same Day 2. The group chest X-ray event revealed and reported one probable case, Su-17. Su-17 was a 16-year-old young man, also an aboriginal youngster. His chest X-ray revealed that there were cavities in his lungs. Due to this further development, all ten schoolteachers and staff having contacts with the class before, duly underwent the required chest X-ray exam. Fortunately, they all got a clean bill of health this time (Table 1).

A. Sn-16 had 7 family members living at home, and all their chest X-ray checkups turned out to be normal. Sn-16 used to attend HS-A, in the Class A-3 and transferred to HS-C, Class C-1 in 2004. So all her classmates, old and new, in both classes and her close friends were notified to have chest X-ray examinations. Every one tested turned out to be normal except one male classmate of hers at HS-C, Class C-1, Su-17, whose seat happened to be next to hers. He was a known TB case. When Sn-16 attended HS-A, she lived in the school dormitory and much of her leisure time was spent at a Japanese language club, and thus she stayed on campus most of the time. After the transfer, other than attending classes at school and activities held by a guitar club, she worked part-time at a fashion store run by a paternal aunt. Being quite busy, she hardly found time to chat with her neighbors. We think

her most likely infection source was her classmate Su-17 at HS-C.

B. Su-17 was found and duly reported as a TB case on March 2, 2004 through that contact chest X-ray checkup. However, he disappeared and could not be reached ever since. We have no record of his contact history or activity history whatsoever.

Discussion

This study began with the accidental discovery of some TB cases in three independent schools in Hualien County. Since they all somehow involved HS-A, it made us suspect this might be a cluster type outbreak (Figure 1). However, after further analyzing epidemiological investigation results, we found all available evidence tended to support a different scenario, i.e. the infections came from family members instead and not from HS-A. From this study we verified the extremely complicated nature of TB infection. Besides characteristically being a chronic disease, TB often has a rather long latent phase or incubation period before onset, and it is often hard to differentiate re-infection and recurrence afterwards [10]; factors such as the Hualien mountainous townships being vast in area, local aboriginals having high rates of risk factors in terms of environment hygiene, accessibility to medical facilities, socioeconomic status, health awareness, and compliance with medicine taking, even genetic susceptibility of infection and some specificity in immune reaction, and so on, all seem to add up to increase the complexity and difficulty of the infection source tracking [11].

If we focus on the “people” factors to study our subjects, the fact is we had 9 student TB cases and student TB contacts, as well as 13 non-student contacts in our study. When we further narrow it down to the students alone, we find that among them, except for the two night school students being age 31 and 23, the

remaining seven students were between 16 and 18 years old, and all at the peak of their physiological development or in the adolescent stage. Another finding is that except for one of the night school students, all student TB cases turned out to be aboriginals. When we take their family contacts into consideration, only two out of the nine TB-positive students had no known TB history in their immediate family members. To sum up the above facts, we can see that two things seem to be quite typical for Hualien area student TB prevalence, and they are: high incidence rate among aboriginals and high rate among those with a family history of TB. We were somewhat surprised to find that TB, which used to more often selectively attack the elderly, has now become more active among adolescents who have better immunity in general. One of the reasons for this outcome very likely has a lot to do with the complicated family disease history of the sufferer. Most newly found cases in this study lived at home and had at least one TB patient also living in the same household. It seems obvious that close contacts would lead to an increase in exposure to TB bacteria. The cases of Cn-8 with a complicated TB family history and Dn-4 with likely spreading of the disease among kin are particularly significant, as not only do they provide clear evidence to support the scenario of the source of infection being in the family, but they also point out the seriousness of infection among family members. Furthermore, the higher than average incidence rate of contracting TB in aboriginals may indicate that there is a susceptibility difference between different ethnic groups [11], and which results in their higher risk of contracting TB. But this presumption can only be proven or disproved by further investigation.

In terms of “geographic” factors, more detailed studies conducted through on-site investigations on school activity range and relative geographic localities revealed one common phenomenon shared by all three schools: that is, the chance

of two students from different classes showing up together at the same spot or simply being close are quite low. At HS-A for instance, Hw-1 and Hu-3 were Class A-1 classmates and they also often were together after school hours, but Dn-11 and Sn-16 belonged to Classes A-2 and A-3, respectively. Most students of any one of these three classes seldom had any social contact with the other two classes. They did not even share their extracurricular interests and school social clubs; they usually went to places and did things only accompanied by their classmates, or alone. The only place on the school grounds where non-classmates might run into one another was the school supply store, but normally they did not loiter there long enough to consider the place as an obvious common contact location for TB infections. In the chest X-ray screening event conducted at VHS-B, we discovered and later confirmed six TB cases including four day-school students and two night-school students. Although the latter, Cu-6 and Yu-7 were classmates, their seats in the classroom were far apart and they seldom talked to each other before class, or chat with the four day-school TB cases. As for the day-school sufferers, they all belonged to different grades and different classes. They each used separate classrooms when attending school, the localities where each participated in extracurricular activities were not the same either. After every available piece of evidence and circumstance had been weighed carefully, we concluded since Sn-16 started to show clear symptoms of TB only a few months after she transferred to HS-C, that her infection source could very well be the classmate in the seat next to hers, Su-17. Despite the fact that TB has been traditionally considered simply a chronic ailment, recent studies elsewhere repeatedly pointed out short-term contact could also cause infection [12, 13]. Therefore, short-term contacts would not exclude the possibility of TB bacteria transfer between two individuals. To sum up this study we can see that

only between Hw-1 and Hu-3 of HS-A, Class A-1, as well as Sn-16 and Su-17 of HS-C, Class C-1, was there any epidemiological link with the school environment, and the connection between these two pairs, if any, had absolutely nothing to do with the fact that Sn-16 transferred from HS-A to HS-C.

In terms of “timing” factors, we noticed that the four HS-A student TB cases, who were also somehow suspected to be involved in the TB cases of the other two schools had very close reporting dates indeed: i.e. HS-A’s Hw-1 was reported as a TB case when he went to see a doctor on December 22, 2003; his classmate Hu-3 was reported on January 9, 2004 when he took chest X-ray examination as one of Hw-1’s contacts; Sn-16 was found and reported on March 1, 2004, only shortly after she transferred from HS-A to HS-C; and another VHS-B student Dn-11 was reported on February 28, 2004 from a contact examination after a positive case was reported in the sampling screening event. The important clue here was their reporting times being significantly close and all fell within a period of 70 days. Combined with the “geographic” factors described above, we started to imagine the possibility of all TB cases of the three schools being somehow connected to one another as one big cluster outbreak with a common source. However, after careful comparison and further analyses, hard evidence led us to believe our former assumption was not true, and they didn’t share a common infection source after all, but the majority of them contracted the disease from their own family members. Recently, many researchers discovered that laboratory molecular typing technology such as spoligotyping applied to TB epidemiological studies could successfully track down and differentiate its infection sources [14, 15]. In the near future, we may follow suit and adopt such technology in our continuous pursuing and further analyzing the epidemiological link of the TB cases in the Hualien area, so we can use more objective laboratory

data to authenticate epidemiological investigation results and hopefully make them more reliable and convincing.

Conclusion

Through the efforts of this study, we have put together a more credible picture showing the TB infection pattern and route of spread among students with TB in the Hualien area, which is not what we originally suspected. To put it succinctly, the majority of students with TB in this area are by far aboriginals, who were most likely infected by their own family members. Therefore, when we are dealing with the issue of TB prevention and control in students in the future, we recommend that the local health authorities should consider adding regular checkups for those who have family members with TB. In addition, we have to point out one more thing before ending this report: this study is by design retrospective research, which heavily relies on people's memories of past events in connection with a notorious slowly developing chronic disease like TB, it is almost impossible to avoid some discrepancies between memory and what really occurred.

Acknowledgement

We are very grateful to our colleagues working at the Disease Control Unit of Hualien County Health Bureau, Chian Township Health Station, and Shoulin Township Health Station for their kind assistance with our epidemiological field studies.

References

1. Daniel TM: Tuberculosis. In: Wilson JD, Braunwand E, Isselbacher KJ, eds. Harrison's Principles of Internal Medicine, USA: McGraw-Hill. 1995:

710-718p.

2. Kochi A: The Global Tuberculosis Situation and the New Control Strategy of the World Health Organization. *Tubercle* 1991; 72: 1-6.
3. Snider DE: Tuberculosis: the World Situation. History of the Disease and Efforts to Combat It. In: Porter JD, McAdam KP, eds. *Tuberculosis: Back to the Future*. New York: Wiley. 1994: 13-33p.
4. WHO: Report on the Tuberculosis Epidemic. TB Group at Risk Executive Summary. 1996.
5. Festenstein F, Grange JM: Tuberculosis and the Acquired Immune Deficiency Syndrome. *Journal of Applied Bacteriology*. 1991; 71: 19-30.
6. Ke HW, Lan CC: Why tuberculosis counterattacks and its control. nosocomial infection control. 1996; 6: 340-342. (in Chinese)
7. Yang SY: The eighth survey of tuberculosis prevalence rate in Taiwan region. *Yi Chin Bao Dou*. 1994; 10: 10-11 (in Chinese)
8. Taiwan CDC: Annual report of communicable disease statistics and surveillance in Taiwan region for 2003. Taipei, Taiwan CDC, pp. 124-133. (in Chinese)
9. Lu BY, Wong KF, Wu YC: A report of tuberculosis sample screening for hospitals and schools. *Yi Chin Bao Dou*. 2004; 20: 420-433. (in Chinese)
10. Grange JM: Immunophysiology and immunopathology. In: Davies DO: *Clinical tuberculosis 3rd eds*. London: Arnold. 2003: 88-104p.
11. Comstock GW: Epidemiology of Tuberculosis. In: Reichmen LB, Hershfield ES: *Tuberculosis. A Comprehensive International Approach 2nd eds*. New York: Basel. 2000: 148p.
12. Van Soolingen D, Borgdorff MW, de Haas PE: Molecular Epidemiology of

- Tuberculosis in the Netherlands: a Nationwide Study from 1993 through 1997. *Journal of Infectious Diseases* 1999; 180: 726-736.
13. Geng E, Kreiswirth B, Driver C: Changes in the Transmission of Tuberculosis in New York City from 1990 to 1999. *New England Journal of Medicine* 2002; 346: 1453-1458.
 14. Alland D, Kalkut GE, Moss AR: Transmission of Tuberculosis in New York City. An Analysis by DNA Fingerprinting and Conventional Epidemiological Methods. *New England Journal of Medicine* 1999; 330: 1710-1716.
 15. Jou R, Huang WL, Chen MH: A prevalence survey of Beijing type tuberculosis bacteria in Taiwan region. *Yi Chin Bao Dou*. 2004; 20: 710-719. (in Chinese)

Table 1. Demographic data of subjects in the study

School	High School C			High School A		
Student case	Sn-16	Su-17	Hw-1	Hu-3	Dn-11	
Age	17	16	18	18	17	
Sex	F	M	M	M	M	
Aboriginals	Yes	Yes	Yes	Yes	Yes	
Detection method	Visiting a doctor	Contact checkup	Visiting a doctor	Contact checkup	Contact checkup	
Date diagnosed	3/01/'04	3/02/'04	12/22/'03	1/09/'04	2/28/'04	
Examination results	CXR (+) M (+)	CXR (+)	CXR (-) M (+)	CXR (-) M (+) C (-)	CXR (+) M (+) C (+)	
Household location	Wanron Township	Tsuosh Township	Chian Township	Shoulin Township		Wanron Township
Non-student contact	None	Not clear	Hw-18	Ka-19	Ka-20	None
Relation to the student case			Father	Mother	Maternal grandfather	
Age			42	43	70	
Aboriginals			Yes	Yes	Yes	
Treatment period			4/03/'03- 5/26/'04	9/09/'02- Still under treatment	Completed managing on 11/07/'85	
Examination results			CXR (+) M (+) C (+)	M (+)	CXR (+) M (-)	
Remarks about the case	Attended HS A before	Contact of Sn-16	Contact of Hw-1		Contact of Dn-4	

Notes: CXR (+)/(-): chest X-ray showing cavity/no cavity; M (+)/(-): Sputum smear positive/negative; C (+)/(-): Sputum culture positive /negative

Vocational High School B									
Dn-4	Ch-5	Cu-6	Yu-7					Cn-8	
18	18	23						16	
M	F	F	F					F	
Yes	Yes	No	Yes					Yes	
CXR screening	Visiting a doctor	CXR screening	CXR screening					Visiting a doctor	
2/12/'04	10/14/'03	2/10/'04	2/16/'04					10/14/'03	
CXR (-)	CXR (+)	CXR (-)	CXR (-)					CXR (+)	
M (-)	M (+)	M (-)	M (-)					M (+)	
C (+)	C (+)		C (+)						
Wanron Township	Hualien City	Chian Township	Hualien City					Shoulin Township	

Dn-12	Ch-13	Ch-14	Yu-15	Cu-21	Cn-22	Ts-23	Cn-24	Cn-25	Cn-26
Brother	Maternal uncle	Friend	Sister	Maternal grandma	Father	Mother	Sister	Brother	Sister
23	27	24	33	69	48	44	23	21	19
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Completed treatment on 3/11/'99	3/23/'01-10/23/'01	7/12/'96-1/07/'97	2/12/'90-11/01/'93	3/05/'03-2/10/'04	4/07/'86-1/25/'88	6/02/'87-4/23/'90	9/29/'00-9/05/'01	1/19/'01-10/20/'01	2/16/'04-9/09/'04
CXR (-)	CXR (+)	CXR (+)	CXR (+)	CXR (-)	CXR (-)	CXR (+)	CXR (+)	CXR (-)	CXR (+)
M (-)	M (+)	M (+)	C (-)	C (+)	C (-)	(+) C (+)	C (-)	M (+)	(+) M (+) C (+)

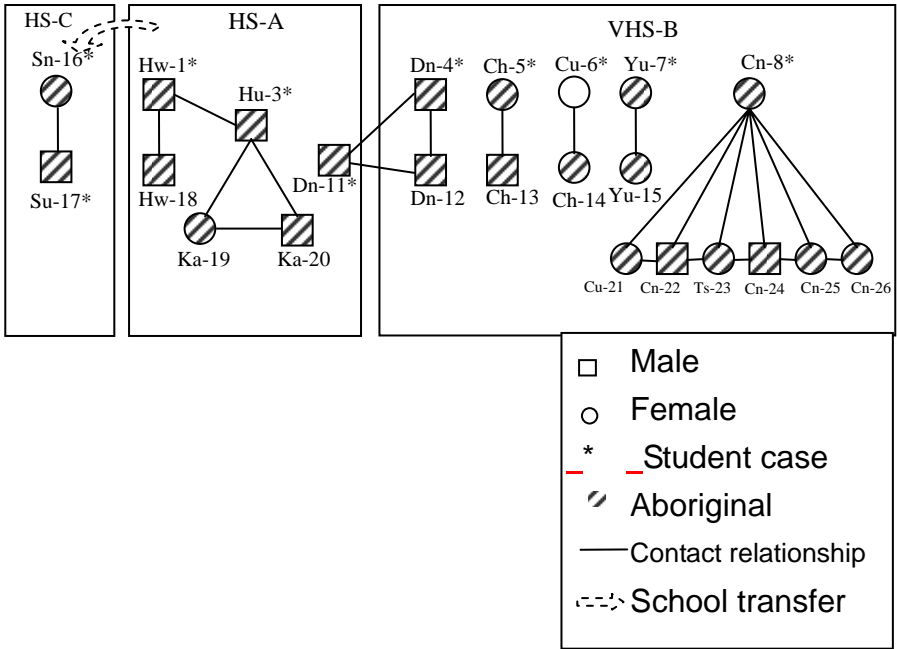


Figure 1. Outline of the relationship among the pulmonary TB cases and contacts