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Epidemiological Characteristics of Pulmonary Tuberculosis in Yangpu District of Shanghai, China, 2006-2015

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Summary

Objective: To characterize the epidemiology of pulmonary tuberculosis in Yangpu district of Shanghai, China, from 2006 to 2015.

Methods: Descriptive analysis was mainly used to summarize the trends and epidemiologic features. The trend of incidence was examined using annual percentage change model. All statistical analyses were conducted using SAS 9.4 and a P value of <0.05 was considered as statistically significant.

Results: A total of 4,408 tuberculosis cases were reported during 2006-2015, with an average annual crude incidence rate of 40.59/10^5 and an Age-Adjusted Incidence Rate (ASIRW) of 28.64/10^5. The incidence was highest in 2008, with a crude incidence rate of 99.04/10^5. The crude incidence rate in males was 56.13/10^5, which was significantly higher than that in female (24.59/10^5, P<0.001). Annual percentage change model showed a general decrease trend in the incidence during this period, with 2 join points observed in 2008 and 2011. The average age of death and onset of the disease were 71.86±13.22 and 50.15±19.63 years, respectively. The proportion of tuberculosis was higher in retired and unemployed populations than in other groups.

Conclusion: A general decrease trend of incidence of tuberculosis from 2006 to 2015 in Yangpu district was observed. Populations of male in gender, relatively low age, and the occupations of retirement and migrant workers or farmers were all more susceptible towards tuberculosis. These findings might provide a comprehensive guide for surveillance and treatment of tuberculosis in Yangpu district of Shanghai.

Keywords: Epidemiology; Incidence; Risk Factors; Tuberculosis

Introduction

Pulmonary tuberculosis (TB), caused by *Mycobacterium tuberculosis* infection, is chronic infectious disease spread through respiratory tract via the air [1]. TB could involve multiple organs including brain, intestines and kidneys from the origin in respiratory system. Patients are the major source of the disease. Along with AIDS and malaria, pulmonary TB has become a reemerging public health problem since 21st century, which draws public attention. According to the data from World Health Organization (WHO), approximately 33% of world population is potentially infected with *Mycobacterium tuberculosis*, more than 90% of which are asymptomatic [2]. Multi-sectional efforts of many countries make it possible to reduce pulmonary TB steadily. However, approximately 1.5 million died of TB in 2014 due to the failure of detection and effective treatment [3-5]. Thus, pulmonary TB is not only a severe public health but also a socio-economic problem worldwide, particularly setting huge burdens on low-resource countries.

China has second largest amount of TB infected patients among 22 pulmonary TB high-burden countries, just after India. Risk factors of TB include HIV co-infection, high density of

population, long-term malnutrition, chronic diseases including diabetes, unhealthy living habits including smoking, gender, and age [6,7]. Multi Drug-Resistant Tuberculosis (MDR-TB) also poses great challenges in TB controlling at present time. As a 2015 WHO survey showed, approximately 500 thousand cases were reported due to MDR-TB, which presented difficulty during controlling and preventing TB effectively. Risk factors mentioned above reveal spreading characteristics and preventive strategies of pulmonary TB.

Shanghai, with a population of more than 20 million till 2018, is one of the most popular and busy city in the world. Facing the Huangpu River and bordering the East China Sea, it has a humid subtropical climate and vast temperature variation during a year. Due to its crowded living environment and unique geographical position and climate condition, several infectious diseases including TB were more prevalent compared with other areas in China [8]. The possible reason for high incidence of TB infection here might be the higher proportion of young and male population, where age between 20 to 40 and male gender are both risk factors of pulmonary TB [9,10]. However, the exact contributing factors of pulmonary TB in Shanghai remain obscure. Yangpu district, located in Northeast of Shanghai, of which the population size remained stable for decades and the medical or living condition was at a medium level, could represent urban Shanghai in TB incidence.

This study described and analyzed the epidemiological characteristics of pulmonary TB cases and trend of incidence of pulmonary TB cases among residents in Yangpu district of Shanghai, China, from 2006 to 2015.

Materials and Methods

Study Area

Yangpu district is one of the 16 districts of Shanghai, China. It locates in the northeastern corner (31°14'N, 121°29'E) of Shanghai and adjacent to lower reaches of Huangpu River, having a total of 1.1 million residents permanently lived in the 60.61 km^2 of land. Yangpu district has estimated a sound disease surveillance system before the year of 2000 and keeps the leading position in disease prevention and control in China since then. This guarantees the quality of the data used in this study.

Source of Data

The surveillance data of TB were derived from the Notifiable Disease Surveillance System (DSS) in Yangpu, Shanghai. The system, covering 39 major infective diseases, had been enhanced since the outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003. According to the National Communicable Disease Control Act of the People's Republic of China, physicians are compulsory to report every case of TB to the local center for disease control and prevention within 24 hours. The TB cases were diagnosed by following criteria:

1. The result of sputum smear was positive;

2. *Mycobacterium tuberculosis* isolation and culture were positive, regardless the result of sputum smear.

3. Diagnosis from pathology of the specimens and clinical symptoms. Baseline information including age, gender, job, residential address, date of onset, and date of death were also collected by the surveillance system.

The yearly demographic data from 2006 to 2015 were obtained from the Public Security Bureau of Yangpu administration.

Statistical Analysis

We examined temporal trends of the incidence from 2006 to 2015 by fitting join point models (Version 4.3.1.0, Bethesda, MD) to the log-transformed, crude rates and age-adjusted rates standardized according to the Segi's world standard population [11,12]. The trend was expressed as an Average Annual Percentage Change (AAPC). The Z test was employed to assess if the AAPC was statistically different from zero. The pairwise comparisons of the trends between groups were evaluated using parallel test. Basic statistical analysis was conducted using SAS9.4 software (SAS, NC). All tests were two-sided. A P value of <0.05 was considered as statistically significant.

Ethics approval

All data were deidentified, and vetting procedures were applied to ensure confidentiality of the enrolled residents.

Results

Epidemiological Characteristics of Infectious TB in Yangpu District of Shanghai from 2006 to 2015

of the 4,408 cases in Yangpu district from 2006 to 2015, 3,092 (70.15%) were males and 1,316 (29.85%) were females with the male to female sex ratio of 2.35. The annual crude incidence ranged from 29.14/10^5 to 99.04/10^5, with the average annual crude incidence rate of 40.59/10^5 and an age-adjusted incidence rate (ASIRW) of 28.64/10^5 during the period. The average crude incidence rate in males from 2006 to 2015 was 56.13/10^5, which was significantly higher than that of 24.59/10^5 in female ($P<0.001$). The incidence rate of TB was highest in the year of 2008 and the crude incidence rates were 134.93/10^5 in males, 61.56/10^5 in females, and 99.04/10^5 in total.

Year	Male			Female			Total		
	Case	Crude incidence	ASR(W)[a]	Case	Crude incidence	ASR(W)[a]	Case	Crude incidence	ASR(W)[a]
2006	233	42.00	26.89	101	19.25	14.84	334	30.94	20.96
2007	287	51.96	34.70	129	24.57	21.02	416	38.61	27.91
2008	744	134.93	97.71	325	61.56	51.22	1069	99.04	74.89
2009	263	47.63	30.68	98	18.43	13.83	361	33.30	22.39
2010	242	43.75	26.57	93	17.36	12.44	335	30.76	19.48
2011	216	39.09	25.24	110	20.39	15.76	326	29.86	20.52
2012	248	44.98	28.29	92	16.99	11.46	340	31.11	19.93
2013	234	42.60	25.77	84	15.50	11.70	318	29.14	18.74
2014	328	59.96	43.04	152	28.05	21.81	480	44.08	32.57
2015	297	54.53	35.58	132	24.35	20.15	429	39.48	27.84
Total	3092	56.13	37.60	1316	24.59	19.49	4408	40.59	28.64
[a]. per/100000 person-year; ASR(W): Age-world-Standardized incidence Rate									

Tab 1: The incidence of TB cases in Yangpu district of Shanghai, from 2006-2015.

Among all the 76 TB caused deaths, 67 (88.16%) were males and 9 (11.84%) were females with the male to female sex ratio of 7.44. The crude mortality rate in males was significantly higher than that in females (P<0.001). The annual mortality rates ranged from $0.09/10^5$ to $3.42/10^5$, with the average annual mortality rate of $0.70/10^5$ during 2005-2016. Compared with the incidence of TB, the mortality also peaked in 2008 where the mortality was $3.15/10^5$ in male, $0.28/10^5$ in female, and $3.42/10^5$ in total.

	Male	Female		Total	
Year	**Death**	**Mortality[a]**	**Death**	**Mortality[a]**	**Death**	**Mortality[a]**
2006	5	0.46	2	0.19	7	0.64
2007	6	0.56	2	0.19	8	0.74
2008	34	3.15	3	0.28	37	3.42
2009	4	0.37	1	0.09	5	0.46
2010	5	0.46	0	0	5	0.45
2011	2	0.18	1	0.09	3	0.27
2012	6	0.55	0	0	6	0.54
2013	1	0.09	0	0	1	0.09
2014	2	0.18	0	0	2	0.18
2015	2	0.18	0	0	2	0.18
Total	67	0.62	9	0.08	76	0.70
[a]. per/100000 person-year						

Table 2: The mortality of TB cases in Yangpu district of Shanghai, from 2006-2015.

Gender-Specific Regression Annual Percentage Change (APC) Model of TB from 2006 to 2015 in Yangpu District and its Age-Adjusted Type

During 2006 to 2015 in Yangpu district, the incidence of TB showed a fluctuating trend in which an upward slope appeared from 2006 to 2008, then declined but ascended slightly again since 2011. As mentioned before, incidence rate of TB in male was higher than that in female, but the trend curves were similar with each other (P=0.897). Also, the trend of crude rates was coincident to that of age-adjusted rates (P=0.799) (Figure 1). There were 2 change points in 2008 and 2011, and a general decrease trend was observed during the whole period.

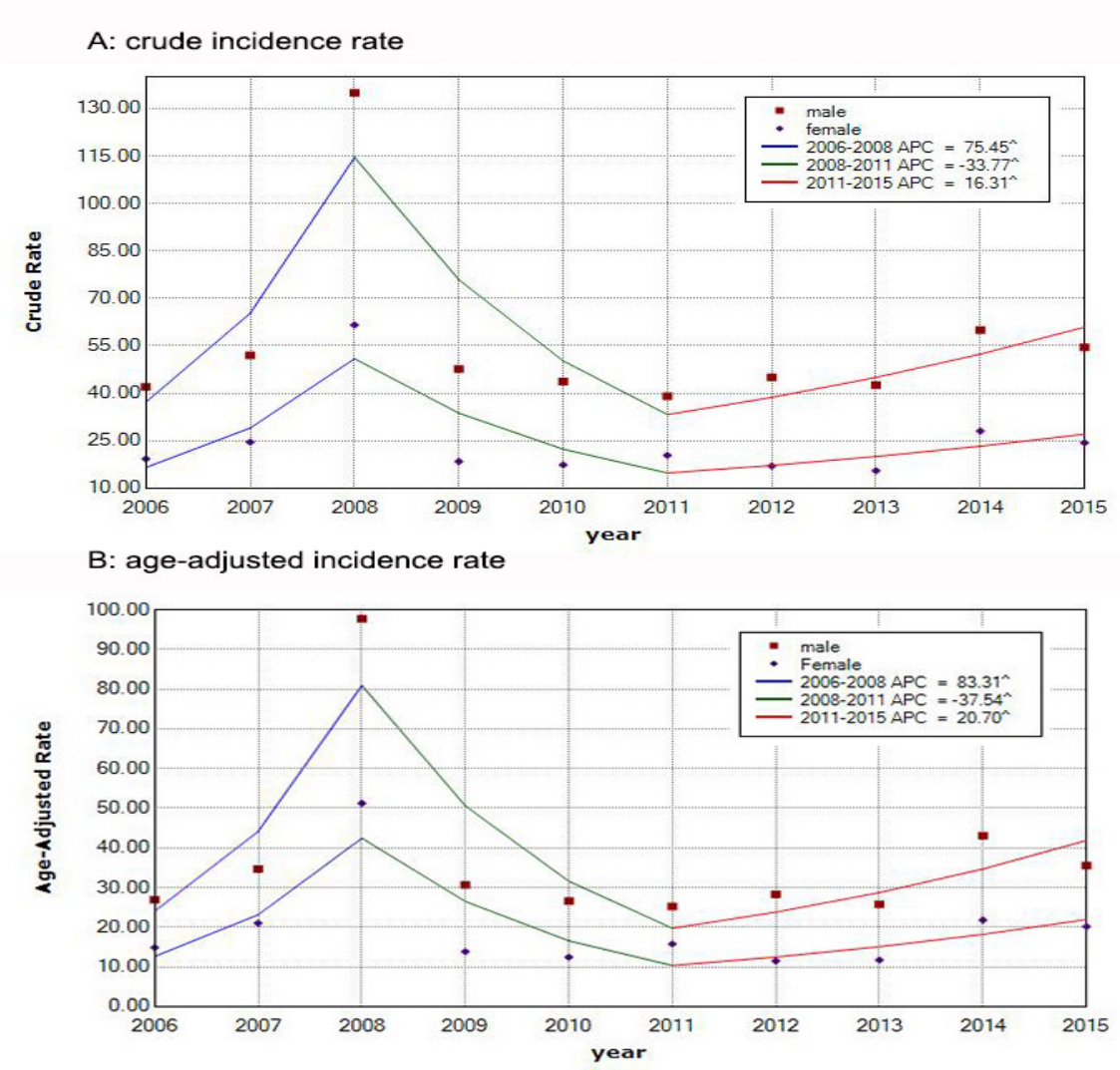

Figure 1: The trends of TB in crude incidence rates and age-adjusted incidence rates during 2006-2015 in Yangpu district, Shanghai.

Occupations of TB Cases from 2006 to 2015 in Yangpu District

To figure out the connection between incidence of TB and occupations, jobs were classified into 6 categories including unemployed, retired staff, farmers or migrant workers, students, and general occupations such as teachers, doctors, businessmen, officers and waiters. During 2006 to 2015 in Yangpu district, proportion of TB cases among retired staff and unemployed remained relatively constant which consisted of more than 50% of all cases, and decrease trend was observed among the other groups except the groups of farmers and migrant workers (Figure 2).

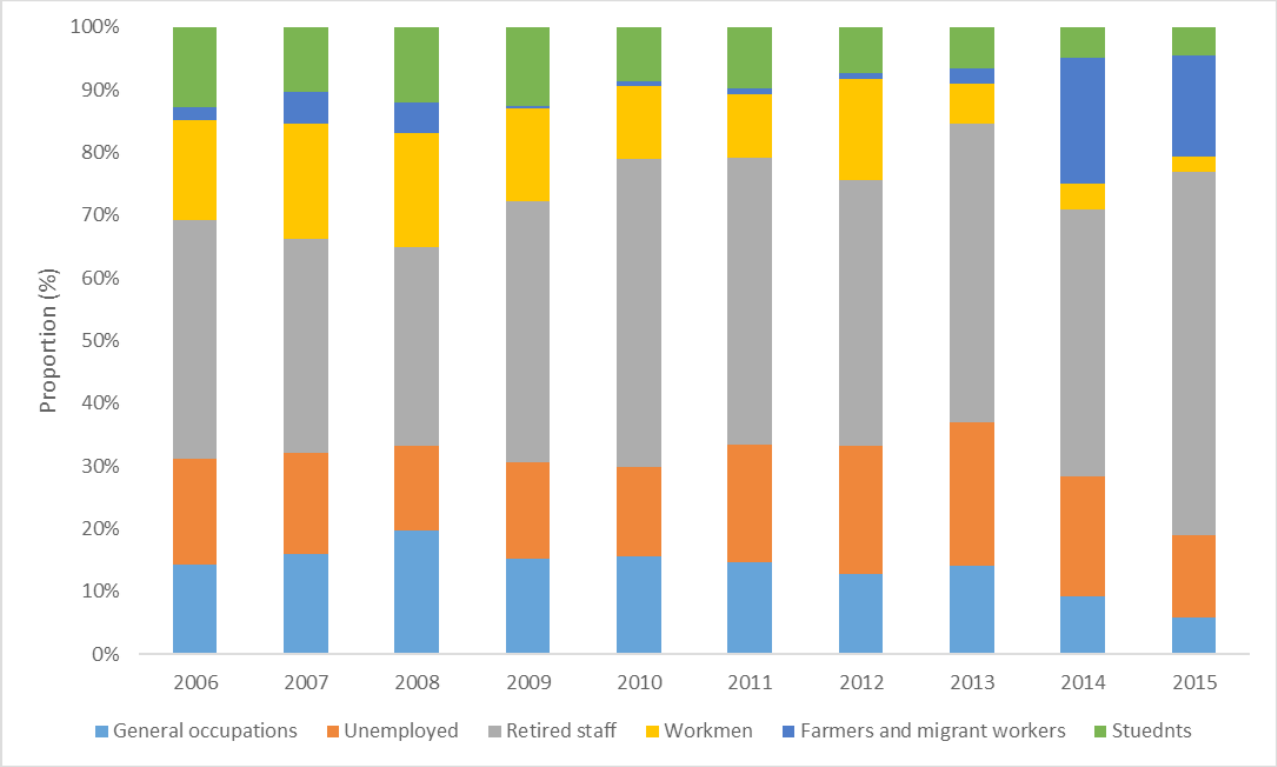

Figure 2: Occupations of TB patients from 2006 to 2015 in Yangpu District.

Age Groups Across Genders of TB Cases from 2006 to 2015 in Yangpu District

For men, incidence of TB was higher in 80 years and older age group (123.45/10^5) and lower in 0-20 years age group (16.81/10^5) during 2006-2015. For women, the the incidence of TB was higher in 20-40 years group (32.66/10^5) and lower in 0-20 age group (13.07/10^5) (Figure 3). The average age of death and onset were 71.86±13.22 and 50.15±19.63 respectively during the whole period.

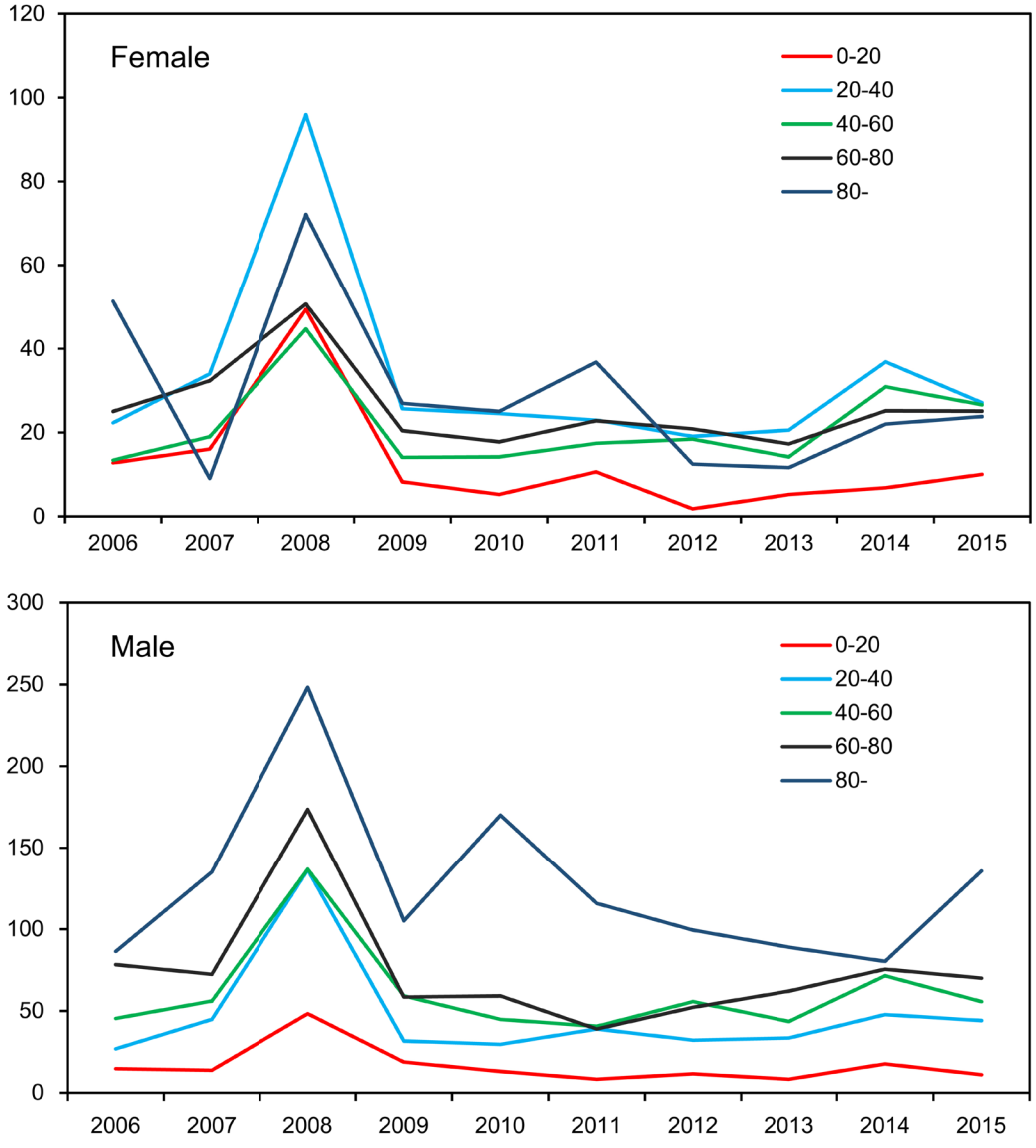

Figure 3: Age-specific incidence rates by sex during 2006-2015 in Yangpu District.

Discussions

This study described and analyzed the epidemiological characteristics of pulmonary TB infection and incidence of pulmonary TB cases among residents in Yangpu district of Shanghai, China, from 2006 to 2015. Once TB cases were diagnosed in hospital or community, they were submitted to local CDC and registered according to the basic criteria. The standard for diagnose and reporting was invariable among different locations and periods. The results revealed that during this period the annual crude incidence ranged from 29.14 to 99.04/10^5 with the average annual crude rate incidence of 40.59/10^5 and an ASIRW of 50.38/10^5, which was relatively high compared with other areas in China although anti-TB strategy was well performed in Shanghai [13,14]. The incidence rate of TB cases was significantly higher in male than female and especially the relatively young adults are more susceptible to TB infection, which was consistent with other researches [15].

According to our study, the incidence trend of TB was a fluctuant type, with the peak in 2008 and bottom in 2011. Since 2008, a lot more people including migrant workers wormed into the city for urban infrastructure when numbers of construction plans including Shanghai Expo were carried out. As economic developed, urbanization also promoted the combination between native residents and external population including farmers around Shanghai, which possibly led to the upward trend from 2006 to 2008 and reached a high point then. A slightly upward slope was observed from 2011 to 2015 because of the change of demography, such as higher proportion of elder citizens due to improvements in public health infrastructure and medical service. However, a general decrease trend was witnessed from 2006 to 2015 in Yangpu district, indicating the improvement of TB prevention and treatment.

When taking occupations of TB cases into consideration, we could find that proportion of TB cases among retired staff and unemployed remained highest of all cases, and increase trend of proportion in the group of farmers and migrant workers was observed. Demographics in Yangpu showed difference with other districts in Shanghai because there existed a large amount of native residents including workmen in large factories, teachers, doctors, drivers and local merchants, who had lived and worked in Yangpu district for whole life and faced retirement afterwards. Due to reduced body immunity and physical health condition among retired staff who were usually elder citizens, primary or recurrent infection of TB was more likely to happen, resulting in higher incidence and mortality of the disease. Migrant workers and farmers, representing floating population, were also the susceptible group towards TB. Thus effective supervision mechanism referring to the transformation from ordinary clinical practice to active surveillance and detection of TB should be performed.

According to the survey, the average age of death and onset were 71.86±13.22 and 50.15±19.63 in Yangpu district from 2006 to 2015, which was contradictory to existed researches to some extent. A possible explanation was the aging population in Shanghai. Along with the development of health care, the life expectancy increased more than 20 years during the past decades, which led to a larger potential TB infected population among elder citizens [16].

As mentioned before, drug resistance was also a critical risk factor for TB infection and set burdens on TB prevention and treatment. Despite national and global efforts, MDR-TB was still a serious health problem, particularly for developing countries [17]. As WHO reported, the MDR incidence rate was approximately 5.3% in 2008 and increased by 1% every year. Chinese government still suffered from the rapid growth rate of MDR-TB [18]. Several factors such as incomplete and inadequate treatment or adherence to treatment, host genetic features, and HIV infection led to the drug resistance. Drug-resistance spectrum towards TB including Isoniazid, Rifampicin, Rifabutin and other kinds of antibiotics showed broad variation among different countries and areas, however the controlling measures seemed to be effective to decrease MDR-TB incidence increasing rate in a global range [19,20]. But as a rare type of MDR-TB called extensively drug resistant TB (XDR-TB) emerged these years, rational drug use and proper treatment still should be emphasized.

Since the 1950s, control of TB has gained attention by government of China and its public health system. The classic Directly Observed Therapy, Short course (DOTS) was implemented till SARS epidemic in 2003. After SARS epidemic had been successfully controlled, it was picked up rapidly to carry on the work of surveillance and prevention of TB again. Thus, new cases of smear-positive tuberculosis had been diagnosed and treated in the country's DOTS program. Also, a new five-year initiative program, announced on 1 April 2009, aims to use innovative technologies to improve the detection and treatment of TB in China. Yangpu government always attached importance on TB control and fully implemented national strategy on controlling TB. Although a general decrease trend of TB incidence was witnessed from 2006 to 2015 in Yangpu district, the situation was still critical for TB prevention in the district and across the whole city. Thus, measures should be taken for future TB prevention as follows, to build overall systems for detection of TB among the retired staff and floating population, to promote public health education to the citizens in Yangpu district and Shanghai, and to advocate rational drug use in community and hospital based on the classic DOTS strategy. The limitation of our study is the lack of information of TB cases from other districts of Shanghai, for which reason we were not able to provide an overall presentation of epidemiological characteristics of pulmonary TB cases.

To sum up, this study described and analyzed the association between the aspects of genders, age and occupations and the incidence as well as mortality of TB infection from 2006 to 2015 in Yangpu district of Shanghai. The result revealed that population of gender in male, age groups of 40-60 in male and 20-40 in female, and the occupations of retirement and migrant workers or farmers were more infected with towards TB. Also, prevention and treatment of MDR-TB should be focused on in the future.

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