Letters

Estimates of Tuberculosis Mortality Rates in China Using the Disease Surveillance Point System, 2004-2010*

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Abstract

Objective To understand the current status and trends of tuberculosis mortality rates in China.

Methods In 2010, 161 National Disease Surveillance Points representing all 31 mainland provinces, municipalities, and autonomous regions of China collected tuberculosis mortality surveillance data, including age, sex, region, and type of tuberculosis (all, pulmonary, and extra-pulmonary). The mortality rates of the three types of tuberculosis were compared between 2004 and 2010.

Results In 2010, the mortality rates due to all tuberculosis, pulmonary tuberculosis, and extra-pulmonary tuberculosis were 4.69 (95% CI 4.54-4.84), 4.38 (4.23-4.52), and 0.31 (0.27-0.35) per 100 000 population, respectively. Mortality rates due to all tuberculosis and pulmonary tuberculosis were higher in males, the elderly, and those living in western and rural areas. From 2004 to 2010, the mortality rates due to all tuberculosis and pulmonary tuberculosis decreased by 36.02% and 37.70%, respectively, with an average annual rate of decline of 7.20% and 7.61%, respectively.

Conclusion Mortality rates due to tuberculosis have declined rapidly in China. The target of reducing the 1990 mortality rate by 50% by 2015 has already been achieved. However, the tuberculosis control program should pay more attention to high-risk groups, including the elderly and those living in underdeveloped areas.

Key words: Tuberculosis, Mortality, Trends

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INTRODUCTION

Tuberculosis (TB) is still a major public health problem worldwide, and especially in China[1-2], where an estimated 1 million new cases were diagnosed in 2010, accounting for 11.4% of the new cases worldwide[1]. Among the 39 notifiable communicable diseases in China, TB ranks third in incidence of reported, behind hand-foot-mouth disease and viral hepatitis[3]. Many activities aimed at controlling the TB epidemic have been undertaken in China since 2000[2,4]. The TB mortality rate is one of the indicators used to assess the effectiveness of the national TB control program (NTP). The NTP's goal of reducing the 1990 TB mortality rate by 50% by 2015 is also one of the

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targets of the United Nations' Millennium Development Goals (MDGs)[5-6].

In China, TB mortality data are derived from retrospective surveys conducted in 1990 and 2000[7-8], the TB management information system which reports case fatality rates of patients registered in the national TB surveillance system, and the Disease Surveillance Point System (DSPS) which generates cause-specific mortality statistics from a nationally representative sample of sites. The retrospective mortality survey has not been repeated since 2001 due to a lack of funding. Mortality rates recorded in the national TB surveillance system underestimate true TB mortality rates because mortality data are missing from those who are undiagnosed or who default on their treatment. The DSPS is considered to be a better measure of the TB mortality rate in China because it provides population-wide data of causes of death on an annual basis[9].

To assess the effects of TB control measures in China, we used TB mortality surveillance data collected by the National DSPS from 2004 to 2010 to analyze the current epidemic and trends in different populations and regions.

METHODS

Data Sources

The Chinese DSPS began in 1978, and included 145 surveillance points by 1990[9]. Since 2004, the 10th revision of the International Classification of Diseases (ICD-10) has been used for coding causes of deaths in the DSPS. ICD codes A15-A19 were categorized as TB. ICD codes A15, A16, and A19 were categorized as pulmonary TB, and ICD codes A17 and A18 were categorized as extra-pulmonary TB.

Stratified cluster random sampling was used to select sample sites within the DSPS[9-10]. The stratified factors included geographic location, Gross Domestic Product (GDP), the proportion of non-agricultural population, and the total population of the county. All counties were categorized as either urban or rural, then stratified based on the above factors.

Currently, the DSPS includes 64 urban and 97 rural surveillance sites in the 31 mainland provinces, municipalities, and autonomous regions, accounting for about 5.6% of the national population. These locations have a combined population structure similar to that of the national census[10-11].

Data Collected by the DSPS

All deaths in the population surveyed by the DSPS were recorded regardless of the place of death, including hospitals, at home with family, and other places. Those recorded as having died at a hospital included those who died before and after arriving at the hospital, and the treating doctors made a diagnosis and completed the medical certificate of death. For those who died at home, the local health provider was responsible for completing the medical certificate of death based on the disease history, symptoms, and cause of death provided by family or relatives. In cases of unexpected death, the local health provider completed the certificate based on other related information, such as police reports.

The medical certificate of death lists the cause and place of death, and demographic information including name, sex, age, address, nationality, occupation, marital status, and educational background. Causes of death are determined using a mixture of medical certification and 'verbal autopsy' procedures, using standard guidelines at all sites to ensure data quality. Most TB deaths were diagnosed based on clinical symptoms and laboratory examination results. Individual death information is entered into the web-based National Vital Registration System by the local county's Centers for Disease Control (CDCs), and validated by upper-level CDCs before being entered into the national database of causes of death.

Data Quality Control

Periodic evaluations for completeness of registration were conducted once every 3 years on a sample of 5 000 households, with subsequent corrections for under-reporting of deaths. Statistical techniques based on "Capture-Mark-Recapture" methods were used to estimate the completeness of registration[12]. The latest survey was conducted in 2009[13], and showed that the total crude rates of under-reporting across the country before and after adjustment by weight were 16.68% and 17.44%, respectively.

The underreporting rates in 2004-2005 and 2009-2010 were calculated using combined general growth balance and synthetic extinct generation methods, which derive very precise estimates for underreporting of DSPS data[14].

Statistical Analysis

We compared mortality rates by age, sex, and type of TB (all TB, pulmonary TB, and extra-pulmonary TB). Descriptive statistics were used to present the data. Comparisons of mortality rates

among different populations and regions were conducted using the Poisson test, with $P \leqslant 0.05$ regarded as statistically significant. Statistical analyses were conducted using SPSS version 17.0 software.

The crude TB mortality rate was adjusted according to methods used for complex sampling surveys[15-16], then adjusted again based on the under-reporting rate, so that mortality rate = adjusted rate/(1 – under-reporting rate).

RESULTS

TB Mortality Epidemic in 2010

The 2010 data from 161 DSPS sample sites included 78 287 479 individuals, with 2 641, 2 444, and 197 deaths, respectively, due to all TB, pulmonary TB, and extra-pulmonary TB. The adjusted mortality rates due to all TB, pulmonary TB, and extra-pulmonary TB were 4.69, 4.38, and 0.31 per 100 000 population, respectively. After adjusting for the population structure in 2000, the mortality rates due to all TB, pulmonary TB, and extra-pulmonary TB were per 3.20, 2.96, and 0.24 per 100 000 population, respectively.

The average age at death due to all TB, pulmonary TB, and extra-pulmonary TB was 61.02 (95% CI 60.30-61.74), 62.25 (61.55-62.95), and 45.70 (42.19-49.22) years. The distributions by age, sex, educational background, and region of individuals who died due to TB are shown in Table 1.

TB Mortality Rates by Age and Sex

The mortality rates for all TB, pulmonary TB, and extra-pulmonary TB were much higher in males than in females ($P<0.05$).

The Poisson regression test results for all TB, pulmonary TB, and extra-pulmonary TB support the hypothesis that mortality rates increase as age increases (Table 2, Figure 1).

Table 1. The Distribution Characteristics of Patients who Died from TB in 2010

		TB case		PTB case		Extra-PTB	
		No.	%	No.	%	No.	%
Sex	Male	1 863	70.54	1741	71.24	122	61.93
	Female	778	29.46	703	28.76	75	38.07
Age	<15	41	1.55	13	0.53	28	14.21
	15~	164	6.21	134	5.48	30	15.23
	30~	345	13.06	306	12.52	39	19.80
	45~	531	20.11	496	20.29	35	17.77
	60~	1 560	59.07	1 495	61.17	65	32.99
Educational	illiterate	875	33.13	807	33.02	68	34.52
Background	Primary school	1 121	42.45	1 058	43.29	63	31.98
	high school	594	22.49	537	21.97	57	28.93
	university	51	1.93	42	1.72	9	4.57
Region	Eastern	757	28.66	704	28.81	53	26.90
	Central	637	24.12	588	24.06	49	24.87
	western	1 247	47.22	1 152	47.14	95	48.22
Population	urban	872	33.02	776	31.75	96	48.73
Type	rural	1 769	66.98	1 668	68.25	101	51.27

Table 2. TB Mortality Rates by Age and Sex in 2010 (per 100 000 Population)

	Population	TB Case		*P* Value	PTB Case		*P* Value	Extra-PTB		*P* Value
		No.	Rate		No.	Rate		No.	Rate	
Male	39932567	1863	5.20	<0.05*	1741	4.88	<0.05*	122	0.32	<0.05*
Female	38354912	778	2.19		703	2.02		75	0.17	
<15	13922559	41	0.31		13	0.09		28	0.22	
15~	18582316	164	0.94		134	0.78		30	0.16	
30~	19461862	345	1.85	<0.05#	306	1.66	<0.05#	39	0.19	<0.05#
45~	16379014	531	3.63		496	3.41		35	0.22	
60~	9941728	1560	17.64		1495	17.06		65	0.58	

Note. *: Poisson test; #: Poisson regression test.

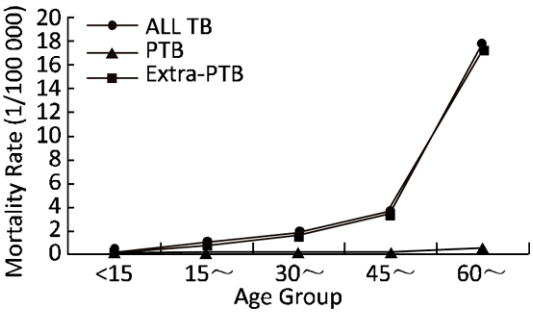

Figure 1. TB mortality rates by age in 2010.

TB Mortality Rates by Region and Population Type

The western region of China had the highest mortality rates for all TB, pulmonary TB, and extra-pulmonary TB, at 6.60, 6.12, and 0.48 per 100 000 population per year, respectively.

The mortality rates for all TB and pulmonary TB were much higher in rural areas than urban areas (P<0.05) (Table 3).

TB Mortality Rate Trends

The average annual mortality rates due to all TB, pulmonary TB, and extra-pulmonary TB from 2004-2010 were 5.90 (5.84-5.97), 5.59 (5.52-5.65), and 0.32 (0.30-0.33) per 100 000, respectively.

The Poisson regression test results for all TB and pulmonary TB support the hypothesis that mortality rates decrease with increasing age group. From 2004 to 2010, the mortality rates due to all TB and pulmonary TB decreased by 36.02% and 37.70%, respectively, with an average rate of decline of 7.20% and 7.61% per year, respectively (Table 4).

Table 3. TB Mortality Rates by Region and Population Type in 2010 (per 100 000 Population)

	Population	TB Case		*P* Value	PTB Case		*P* Value	Extra-PTB		*P* Value
		No.	Rate		No.	Rate		No.	Rate	
Eastern	30047673	757	2.44		704	2.30		53	0.14	
Central	26669521	637	2.41	<0.05	588	2.26	<0.01	49	0.15	<0.05
Western	21570285	1247	6.60		1152	6.12		95	0.48	
Urban	29334727	872	2.94	<0.05	776	2.63	<0.01	96	0.31	<0.05
Rural	48952752	1769	3.90		1668	3.68		101	0.22	

Table 4. TB Mortality Rates from 2004 to 2010 (per 100 000 Population)

Year	Population	TB Case*		PTB Case*		Extra-PTB**h	
		No.	Rate	No.	Rate	No.	Rate
2004	72331209	4254	7.33 (7.14-7.54)	4067	7.03 (6.84-7.23)	187	0.30 (0.26-0.35)
2005	72786469	4327	7.45 (7.26-7.65)	4128	7.13 (6.93-7.32)	199	0.33 (0.29-0.37)
2006	73195361	2791	5.74 (5.56-5.91)	2636	5.43 (5.26-5.60)	155	0.31 (0.27-0.35)
2007	73671176	2701	5.35 (5.18-5.51)	2534	5.04 (4.88-5.20)	167	0.31 (0.27-0.35)
2008	75140291	2488	4.31 (4.16-4.46)	2335	4.04 (3.90-4.18)	153	0.27 (0.23-0.31)
2009	76791489	2486	4.64 (4.49-4.79)	2318	4.33 (4.19-4.48)	168	0.30 (0.27-0.34)
2010	78287479	2641	4.69 (4.54-4.84)	2444	4.38 (4.23-4.52)	197	0.31 (0.27-0.35)

Note. *: Poisson regression test, P<0.05; **: Poisson regression test, P>0.05.

DISCUSSION

The data used in this study were collected from the Chinese DSPS, which accounts for almost 6% of the national population. An analysis by the China CDC showed that the district and population structures of the population sample in the DSPS were the same as in the national census, demonstrating that the DSPS was representative of the national population in both urban and rural areas. Therefore the national mortality data can be represented by mortality data from DSPS[10].

TB is the leading cause of death from a single infectious agent[17], and ranks among the top 10 causes of death worldwide[18]. The results of this analysis confirm that TB mortality rates are falling in China. The mortality rates due to TB, pulmonary TB, and extra-pulmonary TB were 4.69, 4.38, and 0.31

per 100 000 population, respectively, in 2010. An estimated 63 000, 59 000, and 4 000 deaths, respectively, occurred in patients with TB, pulmonary TB, and extra-pulmonary TB in 2010. According to World Health Organization (WHO) estimates, TB mortality rates vary significantly in different parts of the world. In 2010, the average global TB mortality rate was 15 deaths per 100 000 population, with 1.4 million deaths in total[1]. Among the 22 high TB-burden countries, the highest TB mortality rate was 60.8 deaths per 100 000 population in Cambodia, the second lowest was China, and the lowest was 2.6 per 100 000 population in Brazil[1].

The results of this analysis show that the male mortality rate due to all TB in 2010 was almost 137% higher than the female rate, with the highest age-specific mortality rate (17.64 per 100 000) occurring in individuals aged over 60 years. These rates are similar to those reported in other studies[19-20]. Possible explanations for the TB mortality rate being significantly higher among men than among women are that the reported incidence rate of pulmonary TB is nearly always higher among men than among women[21,1] and that men are less likely to complete a full course of treatment than women[21]. The high TB mortality rates among the elderly could be explained by the higher prevalence of TB among the elderly, the greater likelihood of atypical TB presentations in the elderly, and the greater susceptibility to other diseases in the elderly which could result in delayed diagnosis and treatment[22].

The western region of China has the highest TB mortality rate in the country, and mortality rates are much higher in rural areas than urban areas. This could be due to higher TB notification and prevalence rates in western and rural areas[23]. It could also be an indication that TB mortality rates are inversely associated with economic development and accessibility of healthcare services.

The mortality rate for all TB was 9.8 per 100 000 in 2000[8], and had declined by 67.35% in 2010, with an average annual rate of decline of 10.59%. The annual decline of prevalence of pulmonary TB between 2004 and 2010 was 7.61% in average, which was faster than expected[23]. The declining TB mortality and prevalence rates indicate that TB control measures have achieved a significant difference in recent years in China. The declining TB mortality rate is partly due to the declining rates of TB incidence and case fatalities[24].

The WHO estimates that the incidence rate of TB has declined by 1% per year in China since 2004[25]. Since 2000, the Directly Observed Treatment Short-course (DOTS) strategy has been scaling up in China, and funding for TB control has increased dramatically[2,4]. By 2005, 100% of counties had implemented the DOTS strategy, and case detection and treatment success rates of new smear-positive cases reached 80% and 90%, respectively[2]. Data from the TB surveillance system indicate that the three key indicators of global targets for TB control have remained at a high level since then. These factors could explain the declining TB case fatality rate.

Data from the comprehensive national survey in 1990 indicated a mortality rate due to all TB of 20.4 per 100 000[7] (adjusted for population structure in 2000: 24.20 per 100 000). The mortality rate due to all TB was 86.78% lower in 2010 compared to 1990. The decline averaged 18.32% per year. This means that one of the MDG targets for TB control, namely to halve the 1990 mortality rate by 2015, has already been achieved in China.

There are two limitations to this analysis. First, the mortality data used in this study is based on the Chinese DSPS, which is a sample vital registration system. The representative accuracy of this system is affected by social, economic, and population changes[10]. Because it is only a sample vital registration system and not a national vital registration system, it is not the best measure of TB mortality rates. However, the sample vital registration system is recommended by the WHO as a viable method of measuring TB mortality rates when there is a poorly developed or undeveloped national vital registration system[18]. Second, TB mortality rates may be underestimated due to absent or incorrect classifications of death, especially for individuals who died at home or in rural areas[26], were co-infected with HIV, were malnourished, or had concurrent lung cancer. In these cases, TB may not have been recorded as a direct or contributory cause of death[24,27]. In this analysis, TB mortality rates were adjusted based on the results of periodic under-reporting surveys.

In conclusion, there has been substantial progress in TB control and prevention in China, and TB mortality rates have declined rapidly. The target of reducing the 1990 mortality rate by 50% by 2015 has already been achieved. However, further efforts to improve TB control should be focused on high risk groups, including the elderly and those living in

underdeveloped areas. Periodic completeness and accuracy evaluations are necessary to ensure the validity of mortality data.

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