



Contents lists available at ScienceDirect

Journal of the Formosan Medical Association

Journal homepage: <http://www.jfma-online.com>

Original Article

Trends in Tuberculosis in Taiwan, 2002–2008

Hsiu-Yun Lo,^{1,2} Pesus Chou,¹ Shiang-Lin Yang,² Cheng-Yi Lee,^{2,3} Hsu-Sung Kuo^{1,2}*

Background/Purpose: Tuberculosis (TB) remains an important infectious disease in Taiwan. To control TB effectively, the Taiwan Centers for Disease Control implemented the National Tuberculosis Program (NTP) in 2006, modeled on the World Health Organization global TB control program. The goal of the program was to reduce the number of TB cases by half within a decade. This study was designed to describe the epidemiology of TB in Taiwan, and to evaluate the preliminary effectiveness of the NTP.

Methods: We conducted a retrospective study of data from the National Tuberculosis Registry System collected between 2002 and 2008. Demographics, geographic distribution of disease, and change in rates of TB incidence and mortality were analyzed.

Results: From 2002 to 2008, new TB cases declined from 16,758 to 14,265, and incidence decreased from 75 per 100,000 population to 62 per 100,000 population. More than 50% of new cases occurred among elderly adults. Over the study period, TB mortality decreased from 5.7 per 100,000 population, with over half of TB deaths occurring among patients aged ≥ 65 years. Since the NTP was implemented, from 2005 to 2008, TB incidence and mortality declined by 14% and 23%, respectively.

Conclusion: TB-associated incidence and mortality decreased over the course of the study. Nevertheless, there continue to be high-incidence areas that show the opposite trend; these areas should strive to improve case management and consultation. In the most populous districts, rigorous surveillance is necessary to track incidence and mortality rate fluctuations.

Key Words: incidence, mortality, Taiwan, tuberculosis

Tuberculosis (TB) is one of the most serious infectious diseases worldwide. In 2006, there were 9.27 million new cases of TB, and 1.77 million TB-related deaths.¹ Although TB incidence and mortality rates have consistently fallen over the past 50 years in Taiwan, TB is still a major

infectious disease and cause of death in the country. In 2008, Taiwanese TB incidence was 62 cases per 100,000 population, compared with recent estimates from the United States, Japan, Singapore, Hong Kong, Republic of Korea and Vietnam of 4.4, 20, 26, 62, 88 and 173, respectively.^{1,2}

©2011 Elsevier & Formosan Medical Association

¹Institute of Public Health, Community Medicine Research Center, National Yang-Ming University, ²Centers for Disease Control, Department of Health, and ³Institute of Health Policy and Management, College of Public Health, National Taiwan University, Taipei, Taiwan.

Received: April 21, 2010

Revised: July 20, 2010

Accepted: August 10, 2010

***Correspondence to:** Dr Hsu-Sung Kuo, Centers for Disease Control, Department of Health, 6 Linshen S. Road, Taipei 10050, Taiwan.
E-mail: hss@cdc.gov.tw

Despite decreasing TB-associated mortality in Taiwan, in 2008, TB was still ranked the 15th highest cause of death, with three deaths per 100,000 population. By contrast, the mortality rates in the United States, Singapore, Japan, Hong Kong, Republic of Korea and Vietnam in 2006 were 0.5, 2, 3, 5, 10 and 7, respectively.¹

In 2006, the Stop TB Plan 2006–2015 was launched by the World Health Organization (WHO), with the goal of halving TB incidence and mortality by 2015.³ To further TB control efforts, in 2006 the Taiwan Centers for Disease Control (CDC) additionally launched the “Program to Halve TB Incidence in Ten Years”, based on the objectives of the WHO. Control efforts included an expanded directly observed treatment, short-course (DOTS) program for sputum-smear-positive cases in 2006, and a DOTS-plus strategy for multidrug-resistant tuberculosis (MDR-TB) patients, which consisted of five medical care teams, conducting therapy for latent TB among children < 12 years of age, and the commissioning of academic institutions to administer intervention programs in 2007.⁴

The aim of the present study was to describe the epidemiology of TB in Taiwan over the past 7 years (2002–2008) and to evaluate preliminary changes in incidence and mortality rates.

Materials and Methods

Data sources and study population

According to the Taiwanese Communicable Disease Control Act, suspected or confirmed TB cases must be reported to the CDC upon physician verification. All data of new confirmed TB cases were obtained from the National Tuberculosis Registry System, which was established in 1994. Records were computerized in 1996, and the system has used internet-based case reporting and management since 2002.⁵ A total of 109,179 new confirmed TB cases were obtained from the National Tuberculosis Registry System and 6,890 deaths due to TB were obtained from the Office of Statistics, Department of Health.

The duration was between January 1, 2002 and December 31, 2008.

TB case definition

A patient was diagnosed with TB if one or more of the following criteria were met: sputum or body fluid and tissue that was smear-positive for acid-fast bacilli and/or culture-positive for *Mycobacterium tuberculosis* complex; clinical and radiographic appearance consistent with TB; or radiographic evidence of improvement or clinical symptom improvement with a course of anti-TB chemotherapy; and excluding nontuberculous *Mycobacterium* and other non-TB diagnosis.

Death due to TB

Mortality was based on death certificates issued by physicians. According to the regulations, all death certificates collected by local health authorities from the Census Office are sent monthly to the Office of Statistics, Department of Health. The underlying cause of death was coded according to the International Classification of Diseases, Ninth Revision, Clinical Modification.⁶ TB-related deaths have been confirmed by outside review by Taiwan CDC since 2002.⁷

Statistical analysis

Midyear population data for Taiwan were obtained from the Department of Statistics, Ministry of the Interior.⁸ The incidence rate was measured as patients diagnosed with TB during a given year divided by the Taiwanese population midyear. Mortality rate was defined as the number of TB-caused deaths in a given year divided by the midyear population of that year. The rate of change was defined as the percent change in incidence or mortality from one year to the next. The age-standard incidence rate was calculated by dividing the number of TB cases in each age group, which measured as the incidence rate of countries via the WHO 2000 age-standardized population, by the total number of the standardized population. Age-specific death rates were calculated in same manner. Excel 2007 was used to calculate all the study data.

Results

Demographic data of verified TB patients from 2002 to 2008 are presented in Table 1. Between 2002 and 2008, the number of new TB cases declined from 16,758 to 14,265, and the incidence rate declined from 75 per 100,000 population to 62 per 100,000 population, reflecting an 17% decline in TB incident rate and an annual mean rate decrease of 3%.

During the 7-year study period, the median age of the cohort increased from 63 years to 66 years, and incidence declined significantly in all age groups except among individuals aged 0–14 years. The incidence rate among men was approximately twice that in women in each year. Incidence declined annually for all age groups; however, the disease burden was felt most acutely in elderly patients, especially in those aged ≥ 65 years. Among incident TB patients, $> 50\%$ were elderly. In fact, those aged ≥ 65 years showed the highest TB incidence rate during the study period, whereas the rate of TB in the youngest age group (0–14 years) remained constant over time compared to that of other age groups.

Of all new cases, $> 90\%$ were pulmonary TB (PTB); extrapulmonary TB accounted for 10.4% of new cases in 2002 and 4.4% in 2008. With all extrapulmonary TB cases, pleural effusion was predominant (approximately 25%), and approximately 7% of cases had tuberculous meningitis during 2002–2008 (data not shown in Table 1). Based on the sputum bacteriology, the rate of smear- or culture-positive PTB increased slightly over the study period.

TB-associated mortality rates and associated factors are presented in Table 2. TB-associated deaths decreased from 1,277 deaths in 2002 to 762 deaths in 2008, and the mortality rate fell from six per 100,000 population to three per 100,000 population. Among TB-associated deaths, more than three times as many deaths occurred among men than women. We found that TB-associated mortality increased with age. The median age of TB patients was 76–79 years, and $> 80\%$ were ≥ 65 years old. The highest burden

of TB mortality continues to be among elderly patients.

The geographical distribution of TB in Taiwan is shown in Table 3. The eastern area consistently had higher TB incidence rates than the Kao-Ping and southern areas. Age-adjusted incidence rate also revealed that the eastern area had higher TB incidence rates, followed by Kao-Ping area. This was particularly true in Hualien County, where the incidence rate was the highest from 2002 to 2008. However, new cases in the eastern area made up only 4% of all cases, whereas the Taipei area consistently contributed the most cases (27–30%) during each year of the study.

The case-mortality rate was consistently highest in the eastern and Kao-Ping areas and lowest in the Taipei area. Even after age adjustment, the eastern area still had the highest case-mortality rate. Incidence and mortality rates between 2005 and 2008 declined by 14% and 23%, respectively. Decreasing incidence between 2005 and 2008 was seen in six parts of the eastern area, which showed the greatest decline of 22% during that period. Among the 25 Taiwanese cities/counties assessed, the greatest decline was seen in Lienchiang County, while cases increased in three jurisdictions. Decreases in mortality rates were seen in all areas except the Taipei area. The central area had the greatest decline during 2005–2008 (34%). For regions with intervention programs started in 2006, Hsinchu County had an 11% increase in incidence in 2006, while in 2007 and 2008, there was an 18% and 19% decline, respectively (Table 4).

Discussion

We found declining rates of TB-associated incidence (17% decline) and mortality (42% decline) from 2002 to 2008 in Taiwan. There was a decreasing trend in case number in 2002–2008, with the lowest number in 2003. During the 2003 severe acute respiratory syndrome outbreak, there was a dramatic decrease in the number of people seeking medical attention,⁹ which might have

Table 1. Characteristics of new tuberculosis cases in Taiwan, 2002–2008

	2002		2003		2004		2005		2006		2007		2008	
	No.	Rate ^a	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Population (thousands)	22,463		22,563		22,647		22,730		22,823		22,917		22,998	
New cases	16,758	75	15,042	67	16,784	74	16,472	73	15,378	67	14,480	63	14,265	62
Sex														
Male	11,528	101	10,540	92	11,682	101	11,403	99	10,604	92	9,973	86	9,835	85
Female	5,230	48	4,502	41	5,102	46	5,069	45	4,774	42	4,507	40	4,430	31
Median age (yr)	63		64		65		65		65		66		66	
0–14	219	5	141	3	143	3	118	3	114	3	115	3	112	3
15–24	1,052	28	935	26	1,030	29	949	27	852	25	776	23	753	23
25–34	1,314	36	1,163	31	1,258	34	1,282	34	1,074	28	1,018	27	1,043	27
35–44	1,775	47	1,449	38	1,600	42	1,535	40	1,373	36	1,310	35	1,279	34
45–54	2,118	71	1,980	63	2,174	67	2,150	64	1,990	58	1,873	54	1,782	50
55–64	2,200	137	2,014	122	2,139	125	2,030	113	1,946	102	1,911	99	1,845	84
65–74	3,659	292	3,146	249	3,452	271	3,216	249	2,704	206	2,592	194	2,589	191
75–84	3,457	553	3,221	486	3,822	545	3,869	524	3,652	474	3,505	440	3,407	417
≥85	964	777	993	747	1,166	819	1,323	864	1,673	994	1,380	750	1,455	737
Site of disease														
PTB	15,005	67	13,721	61	15,489	68	15,262	67	14,357	63	13,678	60	13,624	59
EPTB	1,753	8	1,321	6	1,295	6	1,210	5	1,021	5	802	4	641	3
Sputum bacteriology														
ss ⁺	5,928	26	5,203	23	5,784	26	5,748	25	5,542	24	5,734	25	5,559	24
ss ⁺ /cul ⁺	8,886	40	8,213	36	9,852	44	10,649	47	10,261	45	10,544	46	10,826	47

^aper 100,000 population. PTB = pulmonary tuberculosis; EPTB = extrapulmonary tuberculosis; ss⁺ = sputum smear positive; ss⁺/cul⁺ = sputum smear or culture positive.

Table 2. Case mortality of tuberculosis in Taiwan, 2002–2008

	2002		2003		2004		2005		2006		2007		2008	
	No.	Rate ^a	No.	Rate ^a	No.	Rate ^a	No.	Rate ^a	No.	Rate ^a	No.	Rate ^a	No.	Rate ^a
Death due to TB	1,277	5.7	1,309	5.8	957	4.2	970	4.3	832	3.6	783	3.4	762	3.3
Sex														
Male	998	8.7	1,033	9.2	739	6.4	741	6.4	607	5.2	618	5.3	578	5.0
Female	279	2.5	276	2.5	218	2.0	229	2.0	225	2.0	165	1.5	184	1.6
Median age (yr)	76		77		78		78		78		78		79	
0–14	1	0.0	0	0.0	1	0.0	1	0.0	0	0.0	2	0.0	2	0.1
15–24	3	0.1	5	0.1	5	0.1	2	0.1	2	0.1	3	0.1	3	0.1
25–34	10	0.3	23	0.6	8	0.2	10	0.3	6	0.2	6	0.2	5	0.1
35–44	43	1.1	46	1.2	35	0.9	26	0.7	26	0.7	26	0.7	17	0.5
45–54	85	2.8	95	3.0	70	2.1	63	1.9	51	1.5	41	1.2	44	1.2
55–64	110	6.9	109	6.6	82	4.8	80	4.4	70	3.7	68	3.3	59	2.7
65–74	304	24.3	291	23.0	202	15.8	175	13.5	142	10.8	135	10.1	132	9.7
75–84	511	81.8	518	78.1	373	55.1	407	55.1	359	46.6	322	40.4	299	36.6
≥85	210	169.3	222	166.9	181	127.1	206	134.4	176	104.6	180	97.8	201	101.8

^aPer 100,000 population.

been associated with the lowest TB case number in that year.

Most TB-associated incidence and mortality were seen in the elderly population. Fifty percent of TB cases in Taiwan were seen in people over the age of 65 years. The higher rate of TB in older adults is due in part to reactivation of disease with age. Elderly people, who make up 10% of the total population,⁹ are at higher risk for diabetes mellitus or other immunosuppressive disease.¹⁰ Older age (≥60 years) and comorbid conditions are factors that are independently associated with unfavorable outcomes.¹¹ Consistent with our findings, advanced age was also associated with poor treatment outcomes in a study in Finland.¹² Similar to our findings, the majority of TB patients in other Asian countries were older adults: in Japan, 54.5% were ≥65 years,¹³ and in Singapore, 55% were ≥50 years.¹⁴ Therefore, TB in the elderly population is becoming an important issue for disease control and could influence treatment outcome of TB in Taiwan.

Despite the high rates of TB in the elderly population, incidence rates decreased in every age group in each year of our study, despite the fact

that the distribution of patient ages remained constant throughout the study period. The lowest TB incidence was seen in the youngest age group (0–14 years) in each year of the study. The lowest incidence of TB in the youngest group is related to the effectiveness of BCG (Bacillus Calmette–Guerin) vaccination,¹⁵ or to the shorter exposure period.

The rate of smear- or culture-positive PTB increased slightly over the study period. Since 2002, Taiwan CDC has followed the WHO recommendations to encourage patients with cough lasting >3 weeks to seek medical advice, and to implement a sputum examination policy, as well as the national sputum examination network. Therefore, the increased positive rates might reflect the strengthening and implementation of these policies.

Based on WHO data, the expected percentage of new pulmonary cases that are smear-positive is 65–80%;¹ however, in Taiwan we found a lower smear-positive rate (approximately 50% each year) among PTB patients. This might be explained by the tendency of physicians to use radiography as a diagnostic tool rather than sputum examinations, poor patient adherence to sputum collection,

Table 3. Number and rate of tuberculosis cases by areas in Taiwan, 2005–2008

Districts	Incidence											
	2005			2006			2007			2008		
	No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b
Taiwan total	16,472	73	63	15,378	67	58	14,480	63	52	14,265	62	50
Taipei area	4,464	61	55	4,118	56	49	4,232	58	48	3,980	54	45
Taipei City	1,386	53	42	1,244	47	37	1,280	49	36	1,178	45	33
Taipei County	2,371	64	64	2,191	58	58	2,283	60	57	2,147	56	52
Keelung City	332	85	74	313	80	69	289	74	61	268	69	56
Ilan County	361	78	65	344	75	59	351	76	59	360	78	60
Lienchiang County	4	41	35	4	40	45	3	30	34	2	20	26
Kinmen County	10	15	10	22	30	23	26	33	26	25	30	21
Northern area	1,883	57	52	1,865	56	50	1,698	50	44	1,606	47	40
Miaoli County	332	59	47	296	53	42	225	40	31	254	45	33
Taoyuan County	1,110	59	58	1,087	57	54	1,054	55	51	1,022	52	48
Hsinchu City	189	49	44	196	50	44	181	46	40	134	33	29
Hsinchu County	252	53	47	286	59	50	238	48	40	196	39	32
Central area	3,076	70	64	2,834	64	57	2,708	61	52	2,774	62	52
Nantou County	526	98	77	432	81	62	421	79	57	383	72	52
Changhwa County	1,018	77	63	934	71	57	929	71	55	964	73	55
Taichung County	953	62	62	896	58	56	813	53	49	836	54	49
Taichung City	579	56	57	572	55	54	545	52	50	591	56	52
Southern area	2,671	78	61	2,415	71	54	2,214	65	49	2,325	68	49
Chiayi County	472	85	59	396	71	50	367	66	46	361	66	42
Yunlin County	729	99	71	628	86	60	546	75	50	581	80	53
Tainan City	453	60	55	424	56	70	381	50	44	471	61	53
Chiayi City	144	53	47	136	50	44	170	62	51	145	53	43
Tainan County	873	79	61	831	75	57	750	68	51	767	69	50
Kao-Ping area	3,622	97	84	3,480	93	80	3,020	81	67	2,987	80	65
Pingtung County	1,061	118	95	989	110	87	847	95	73	884	100	75
Kaohsiung County	1,300	105	93	1,215	98	85	1,066	86	72	1,061	85	71
Kaohsiung City	1,238	82	76	1,244	82	75	1,079	71	61	1,009	66	56
Penghu County	23	25	20	32	35	28	28	30	22	33	36	26
Eastern area	756	129	107	666	114	96	608	105	85	593	103	81
Hwalien County	480	138	115	417	120	103	393	114	92	360	105	86
Taitung County	276	115	94	249	105	84	215	92	74	233	100	74

^aPer 100,000 population; ^bWorld Health Organization standard population (2000) has been adopted for age adjusted rate.

or inappropriate sputum-collection techniques used by laboratory technicians. Further examination of the causes of the low smear-positive rate of PTB in Taiwan is warranted.

The TB incidence rate was highest in the eastern area of Taiwan, although it had the greatest decline during 2005–2008. However, this region accounted for only 4% of the total number of new cases in Taiwan. Regions with the highest TB

incidence (approximately 50% of all new cases each year) were the Taipei and southern areas. Preventive efforts in these regions can play a crucial role in the Taiwanese goal of halving the number of cases of TB.

In addition to executing the NTP, Hsinchu County started a special program in coordination with the Community Medicine Research Center, National Yang-Ming University, and Human

Mortality											
2005			2006			2007			2008		
No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b	No.	Rate ^a	Rate ^b
970	4.3	3.6	832	3.6	2.9	783	3.4	2.6	762	3.3	2.5
160	2.2	1.9	169	2.3	1.9	177	2.4	1.9	185	2.5	1.9
60	2.3	1.6	68	2.6	1.6	57	2.2	1.3	69	2.6	1.5
71	1.9	2.1	70	1.9	1.9	85	2.2	2.2	83	2.2	2.1
12	3.1	2.5	8	2.0	1.5	11	2.8	1.9	13	3.3	2.2
16	3.5	2.5	21	4.6	3.3	21	4.6	2.9	18	3.9	2.7
0	–	0.0	0	–	0.0	0	0.0	0.0	0	0.0	0.0
1	1.5	1.0	2	2.7	1.4	3	3.8	2.0	2	2.4	1.5
107	3.3	2.9	107	3.2	2.7	91	2.7	2.2	94	2.8	2.2
38	6.8	4.6	27	4.8	3.2	16	2.9	1.9	15	2.7	1.7
36	1.9	2.0	53	2.8	2.6	54	2.8	2.5	43	2.2	2.0
10	2.6	2.0	15	3.8	3.2	10	2.5	2.0	14	3.5	2.7
23	4.9	4.1	12	2.5	2.1	11	2.2	1.7	22	4.4	3.3
227	5.1	4.6	166	3.7	3.2	157	3.5	2.9	151	3.4	2.7
18	3.3	2.4	17	3.2	2.1	29	5.4	3.5	24	4.5	2.9
124	9.4	7.4	78	5.9	4.4	73	5.6	4.0	57	4.3	2.9
51	3.3	3.5	42	2.7	2.8	33	2.1	2.0	45	2.9	2.7
34	3.3	3.6	29	2.8	2.8	22	2.1	2.0	25	2.4	2.2
152	4.4	3.2	119	3.5	2.4	128	3.7	2.5	111	3.2	2.0
37	6.6	4.3	18	3.2	2.1	13	2.4	1.3	21	3.8	2.2
46	6.3	4.1	39	5.3	3.4	40	5.5	3.3	34	4.7	2.6
20	2.6	2.4	14	1.8	1.5	21	2.8	2.4	16	2.1	1.8
4	1.5	1.3	3	1.1	0.9	9	3.3	2.7	5	1.8	1.3
45	4.1	2.9	45	4.1	2.7	45	4.1	2.5	35	3.2	1.9
261	7.0	6.0	216	5.8	4.8	184	4.9	3.9	185	4.9	3.8
88	9.8	7.3	82	9.2	6.6	73	8.2	5.6	68	7.7	5.4
71	5.7	5.2	60	4.8	4.2	48	3.9	3.2	66	5.3	4.2
101	6.7	6.4	72	4.8	4.4	61	4.0	3.4	50	3.3	2.8
1	1.1	0.8	2	2.2	1.0	2	2.2	2.0	1	1.1	0.4
63	10.7	7.6	55	9.4	6.4	46	7.9	5.9	36	3.4	4.1
33	9.5	6.8	32	9.2	6.3	27	7.8	5.5	24	7.0	4.6
30	12.5	8.9	23	9.7	6.6	19	8.1	6.4	12	5.2	3.4

Rights Education Foundation. This program was designed to compile educational materials on TB prevention and human rights, coordinate efforts with local health bureaus, recruit volunteer health-care workers and organize various community education efforts to help residents learn about signs and symptoms of TB and about treatment options. The program also involves the use of a simple screening method,¹⁶ so that the residents

can be made aware of their lung conditions, receive chest X-ray examinations, and discover silent cases at an early stage. As a result of these efforts, the TB incidence in this region increased in 2006, while the mortality declined. In 2007 and 2008, declines in incidence continued, but the mortality rate rose. Continued assessment of the long-term effectiveness of these prevention efforts is warranted.

Table 4. Changes in tuberculosis incidence and mortality rate in Taiwan, 2005–2008

Districts	% change 2005–2006		% change 2006–2007		% change 2007–2008	
	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality
Taiwan total	-7	-15	-6	-6	-2	-3
Taipei area	-8	5	2	4	-6	4
Taipei City	-10	13	3	-16	-8	21
Taipei County	-8	-2	3	20	-7	-3
Keelung City	-6	-33	-8	38	-7	19
Ilan County	-5	32	2	-	3	-14
Lienchiang County	-2	-	-23	-	-33	-
Kinmen County	102	84	10	39	-9	-37
Northern area	-2	-1	-10	-16	-6	4
Miaoli County	-11	-29	-24	-41	13	-6
Taoyuan County	-4	45	-4	0	-4	-21
Hsinchu City	3	49	-9	-34	-27	38
Hsinchu County	11	-49	-18	-10	-19	97
Central area	-8	-27	-5	-6	2	-4
Nantou County	-18	-5	-2	71	-9	-17
Changhua County	-8	-37	0	-6	4	-22
Taichung County	-6	-18	-10	-22	2	35
Taichung City	-2	-16	-6	-25	7	13
Southern area	-10	-22	-8	8	5	-14
Chiayi County	-16	-51	-7	-27	-1	62
Yunlin County	-13	-15	-13	3	7	-15
Tainan City	-7	-30	-11	49	23	-24
Chiayi City	-6	-25	25	199	-15	-45
Tainan County	-5	0	-10	0	2	-22
Kao-Ping area	-4	-17	-13	-15	-1	0
Pingtung County	-6	-6	-14	-11	5	-6
Kaohsiung County	-7	-16	-12	-20	0	38
Kaohsiung City	0	-29	-14	-16	-7	-18
Penghu County	39	100	-12	0	17	-50
Eastern area	-11	-12	-8	-16	-2	-57
Hualien County	-13	-2	-5	-15	-8	-11
Taitung County	-9	-22	-13	-17	9	-36

In 1947, there were 18,533 deaths due to TB in Taiwan, accounting for 16.2% of the total deaths that year (a rate of 294 per 100,000 population). In 1985, TB was excluded from the top 10 causes of death in Taiwan for the first time.⁵ In 2002, there were <1,000 TB-associated deaths, and in 2004, TB dropped to 13th on the list of causes of death. TB prevention efforts seem to be working, based on declining mortality rates year by year. Nonetheless, the 2008 mortality rate was 3.3 per

100,000 population, which was higher than in developed countries, including the United States (<1 per 100,000 population), Japan (3 per 100,000 population), and Singapore (2 per 100,000 population).¹ Although older age is significantly associated with death,¹⁷ the age distribution of TB patients in Taiwan was similar to that in Japan and Singapore, namely >50% were aged >50 years old; however, the mortality, in those countries was lower than that in Taiwan.

The human immunodeficiency virus (HIV) pandemic presents a massive challenge to TB control programs worldwide.¹⁸ Although, under the implementation of a harm-reduction program in 2006, the number of HIV cases has declined in Taiwan,¹⁹ it is worth noting that HIV is the main reason for failure to meet TB control targets in countries with a high prevalence of HIV infection. If we fail to control HIV effectively, the decline in incidence and mortality rate might be threatened; therefore, close monitoring of HIV-related TB remains essential in Taiwan.

In addition, MDR-TB, a man-made problem, significantly contributes to the TB burden worldwide.²⁰ Molecular epidemiology studies have suggested that some *M. tuberculosis* strains are able to disseminate more quickly than others, and can therefore thwart preventive efforts.^{21–23} Thus, close surveillance of MDR-TB prevalence and vigilant treatment are very important. Although the DOTS-Plus program has been promoted by the Taiwan CDC since 2007, special attention must be paid to MDR-TB according to WHO recommendations.

The purpose of confirming TB-related deaths by physicians of the Taiwan CDC was to improve the accuracy of cause of death, because of overestimates in previous years. However, underestimates of TB-related death might occur due to excessive caution by physicians when cause of death is in doubt, and this might have been a limitation of our study.

In summary, we found that TB-associated incidence and mortality declined in Taiwan from 2002 to 2008. The NTP was implemented in 2006. The initial evaluation of its effectiveness in its first 3 years suggests that it has been effective in reducing TB-associated incidence and mortality. Sustained monitoring of the effectiveness of the NTP is necessary. Furthermore, in cities and counties that have seen an increase in TB, local health authorities and the CDC need to focus their efforts on controlling TB and investigating the reasons for its increase, with special attention paid to rigorous surveillance of rate fluctuations, especially regarding TB incidence.

References

1. World Health Organization. *Global Tuberculosis Control: Surveillance, Planning, Financing: WHO Report 2008*. Geneva: World Health Organization, 2009.
2. Centers for Disease Control and Prevention. Trends in tuberculosis—United States, 2007. *MMWR Morb Mortal Wkly Rep* 2008;57:281–5.
3. Stop TB Partnership and World Health Organization. *Global Plan to Stop TB 2006–2015*. Geneva: World Health Organization, 2006.
4. Centers for Disease Control, Department of Health, Executive Yuan, Taiwan, R. O. C. *Program to Halve TB in a Decade*. Taipei: Centers for Disease Control, Department of Health, Executive Yuan, Taiwan, R. O. C., 2006.
5. Centers for Disease Control, Department of Health, Executive Yuan, Taiwan, R. O. C. *Strategies for Tuberculosis Control: Tuberculosis Annual Report, 2001*. Taipei: Centers for Disease Control, Department of Health, Executive Yuan, Taiwan, R. O. C. 2001.
6. Lu TH, Lee MC, Chou MC. Accuracy of cause-of-death coding in Taiwan: types of miscoding and effects on mortality statistics. *Int J Epidemiol* 2000;29:336–43.
7. Wu YC, Lin RS, Yang SL, et al. Assessing the quality of tuberculosis-related underlying cause of death assignment in Taiwan, 2001–2005. *J Formos Med Assoc* 2008;107:30–6.
8. Ministry of the Interior, Taiwan, R. O. C. *Demographic Fact Book Republic of China*. Taipei: Ministry of the Interior, Taiwan, R. O. C. 2002–2008.
9. Chang HJ, Huang N, Lee CH, et al. The impact of the SARS epidemic on the utilization of medical services: SARS and the fear of SARS. *Am J Public Health* 2004;94:562–4.
10. Willian W, Asim K. Tuberculosis in elderly persons. *Annu Rev Med* 1991;42:267–76.
11. Wang CS, Chen HC, Yang CJ, et al. The impact of age on the demographic, clinical, radiographic characteristics and treatment outcomes of pulmonary tuberculosis patients in Taiwan. *Infection* 2008;36:335–40.
12. Vasankari T, Holmström P, Ollgren J, et al. Risk factors for poor tuberculosis treatment outcome in Finland: a cohort study. *BMC Public Health* 2007;14:291.
13. The Research Institute of Tuberculosis, Japan Anti-Tuberculosis Association. *Statistics of Tuberculosis 2007*. Available at: http://www.jata.or.jp/rit/rj/data_tp.html. [Date accessed: April, 2008]
14. Ministry of Health, Singapore. Tuberculosis surveillance in Singapore, 2006. *Epidemiol News Bull* 2007;33:14–7.
15. Curtis HM, Leck I, Bamford FN. Incidence of childhood tuberculosis after neonatal BCG vaccination. *Lancet* 1984;1(8369):145–8.
16. Fournet N, Sanchez A, Massari V. Development and evaluation of tuberculosis screening scores in Brazilian prisons. *Public Health* 2006;120:976–83.
17. Chiang CY, Lee JJ, Yu MC, et al. Tuberculosis outcomes in Taipei: factors associated with treatment interruption

- for 2 months and death. *Int J Tuberc Lung Dis* 2009;13: 105–11.
18. Elizabeth L, Catherine J, Walker N, et al. The Growing burden of tuberculosis: global trends and interactions with the HIV epidemic. *Arch Intern Med* 2003;163:1009–21.
 19. Chen YM, Kuo SH. HIV-1 in Taiwan. *Lancet* 2007;369: 623–5.
 20. Espinal MA. The global situation of MDR-TB. *Tuberculosis* 2003;83:44–51.
 21. Van Soolingen D. Molecular epidemiology of tuberculosis and other mycobacterial infections: main methodologies and achievements. *J Intern Med* 2001;249:1–26.
 22. Bifani PJ, Mathema B, Kurepina NE, Kreiswirth B. Global dissemination of the *Mycobacterium tuberculosis* W-Beijing family strains. *Trends Microbiol* 2002;10:45–52.
 23. Glynn JR, Whiteley J, Bifani PJ, et al. Worldwide occurrence of Beijing/W strains of *Mycobacterium tuberculosis*: a systematic review. *Emerg Infect Dis* 2001;8:843.