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Trends in Tuberculosis in Taiwan, 2002–2008

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**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 to 3.3 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

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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
|                | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   |
|----------------|--------|--------|--------|--------|--------|--------|--------|
|                | No.    | Rate¹  | 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     |
| Sex           |        |        |        |        |        |        |        |        |
| Male          | 11,528 | 101    | 10,540 | 92     | 11,403 | 99     | 10,604 | 92     |
| Female        | 5,230  | 48     | 4,502  | 41     | 5,102  | 46     | 4,869  | 42     |
| Median age (yr)| 63    | 64     | 65     | 65     | 65     | 65     | 66     | 66     |
| 0–14          | 219    | 5      | 141    | 3      | 143    | 3      | 118    | 3      |
| 15–24         | 1,052  | 28     | 935    | 26     | 1,030  | 29     | 949    | 27     |
| 25–34         | 1,314  | 36     | 1,163  | 31     | 1,258  | 34     | 1,282  | 34     |
| 35–44         | 1,775  | 47     | 1,449  | 38     | 1,600  | 42     | 1,535  | 40     |
| 45–54         | 2,118  | 71     | 1,980  | 63     | 2,174  | 67     | 2,150  | 64     |
| 55–64         | 2,200  | 137    | 2,014  | 122    | 2,139  | 125    | 2,030  | 113    |
| 65–74         | 3,659  | 292    | 3,146  | 249    | 3,452  | 271    | 3,216  | 249    |
| 75–84         | 3,457  | 553    | 3,221  | 486    | 3,822  | 545    | 3,869  | 524    |
| ≥85           | 964    | 777    | 993    | 747    | 1,166  | 819    | 1,323  | 864    |
| Site of disease|       |        |        |        |        |        |        |        |
| PTB           | 15,005 | 67     | 13,721 | 61     | 15,489 | 68     | 15,262 | 67     |
| EPTB          | 1,753  | 8      | 1,321  | 6      | 1,295  | 6      | 1,210  | 5      |
| Sputum bacteriology|      |        |        |        |        |        |        |        |
| ss⁺           | 5,928  | 26     | 5,203  | 23     | 5,784  | 26     | 5,748  | 25     |
| ss⁺/cul⁺      | 8,886  | 40     | 8,213  | 36     | 9,852  | 44     | 10,649 | 47     |

¹Per 100,000 population. PTB = pulmonary tuberculosis; EPTB = extrapulmonary tuberculosis; ss⁺ = sputum smear positive; ss⁺/cul⁺ = sputum smear or culture positive.
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, are at higher risk for diabetes mellitus or other immunosuppressive disease. Older age (≥60 years) and comorbid conditions are factors that are independently associated with unfavorable outcomes. Consistent with our findings, advanced age was also associated with poor treatment outcomes in a study in Finland. Similar to our findings, the majority of TB patients in other Asian countries were older adults: in Japan, 54.5% were ≥65 years, and in Singapore, 55% were ≥50 years. 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, 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%; 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 2. Case mortality of tuberculosis in Taiwan, 2002–2008

| Year | No. | Rate a |
|------|-----|--------|
| 2002 | 1,277 | 5.7 |
| 2003 | 1,309 | 5.8 |
| 2004 | 957 | 4.2 |
| 2005 | 970 | 4.3 |
| 2006 | 832 | 3.6 |
| 2007 | 783 | 3.4 |
| 2008 | 762 | 3.3 |

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aPer 100,000 population.
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

| Table 3. Number and rate of tuberculosis cases by areas in Taiwan, 2005–2008 |
|----------------------------------|-----------------|-----------------|-----------------|-----------------|
| Districts                        | 2005            | 2006            | 2007            | 2008            |
|                                  | Incidence       | Incidence       | Incidence       | Incidence       |
|                                  | No.  Ratea Rateb | No.  Ratea Rateb | No.  Ratea Rateb | No.  Ratea Rateb |
| 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       |
| Changhua 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      |

Per 100,000 population; World Health Organization standard population (2000) has been adopted for age adjusted rate.
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 healthcare 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, 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.

| 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  |
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 years old; however, the mortality, in those countries was lower than that in Taiwan.

### 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 | 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       |
The human immunodeficiency virus (HIV) pandemic presents a massive challenge to TB control programs worldwide. Although, under the implementation of a harm-reduction program in 2006, the number of HIV cases has declined in Taiwan, 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. Molecular epidemiology studies have suggested that some *M. tuberculosis* strains are able to disseminate more quickly than others, and can therefore thwart preventive efforts. 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.

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