

Assessing the Quality of Tuberculosis-related Underlying Cause of Death Assignment in Taiwan, 2001–2005

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Background/Purpose: Assignment of underlying cause of death (UCOD) might be inconsistent among coders if physicians do not properly record cause of death on death certificates. This study aimed to assess the changes in the quality of tuberculosis-related UCOD assignment in Taiwan after interventions by the Center for Disease Control (CDC).

Methods: The reference (gold standard) we used to assess the quality of UCOD assignment by coders was the UCOD selected by the Automated Classification of Medical Entities (ACME) computer program. The agreement, over- and under-coding rates between coders and the reference were calculated by years before and after the CDC interventions.

Results: An abrupt decrease in tuberculosis death rates according to the UCOD assigned by coders was noted from 2003 to 2004, but no such decrease was noted according to the reference. The agreement in UCOD assignments between coders and ACME decreased from 0.75 in 2001 to 0.67 in 2005. We found a significant decrease in the over-coding rate from 0.21 in 2003 to 0.11 in 2004, and a prominent increase in under-coding rates from 0.08 in 2003 to 0.24 in 2004.

Conclusion: The abrupt decrease in the official published tuberculosis mortality rate from 2003 to 2004 was due to significant changes in the practice of UCOD assignment of official coders, which might have been a response to interventions initiated by the CDC. [*J Formos Med Assoc* 2008;107(1):30–36]

Key Words: cause of death, coding, epidemiology, mortality, tuberculosis

The underlying cause of death (UCOD) is defined by the World Health Organization as “the disease or injury which initiated the train of morbid events leading directly to death” and is the cause of death used for tabulating official cause of death statistics in most countries.¹ Ideally, the attending physician of the deceased should determine the UCOD for each death and properly report the causal relationship between cause of death on death certificates.^{2,3} In reality however, many physicians do not properly report the cause of

death, which makes the assignment of UCOD inconsistent among coders.^{4–7}

Cause of death statistics is an important reference for national tuberculosis (TB) control policy planning and evaluation. For example, of 55 statistical tables in the appendix of the *Tuberculosis Annual Report 2001* published by the Center for Disease Control (CDC) of Taiwan, 18 were based on mortality data.⁸ Many scholars also use mortality data to examine the epidemiologic profiles of TB problems in Taiwan.^{9–12} If the quality of TB

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mortality data cannot be ensured, then the validity of the conclusions derived is threatened.

The determination of TB-related UCOD has become progressively more difficult because many elderly people have recurrent TB and comorbid diseases.¹³⁻¹⁵ For example, when an elderly person has chronic obstructive pulmonary disease and recurrent TB that is under treatment, and then dies from acute myocardial infarction, it is sometimes very difficult for the attending physician to determine whether the elderly person had died *from* TB or *with* TB. If the physician thought the elderly person had died *from* TB, then the UCOD would be recorded as TB. In contrast, if the physician thought the elderly person had died *with* TB, the UCOD would not be recorded as TB. A previous study indicated that half of the 2129 death certificates that mentioned TB was inappropriately certified by physicians and that 16% had an inaccurately assigned UCOD by official coders in Taiwan.¹⁶

To improve the quality of the TB-related cause of death certification behavior of physicians and TB-related UCOD assignment of official coders, the Taiwan CDC initiated several interventions in 2002. The aim of this study was to assess the changes in the quality of TB-related UCOD assignment of official coders before and after the CDC interventions.

Methods

Interventions

Since 2002, the Taiwan CDC has asked the Office of Statistics of the Department of Health to mail all TB-related death certificates to them on a monthly basis for quality assurance *before* the official cause of death statistics are published. The CDC can thus assess the accuracy of certification by certifiers, identify the questionable cases and mail them back to the Office of Statistics to consider modifying the UCOD assignment. About 10–15% of death certificates in which TB was originally assigned as the UCOD by official coders were queried by the CDC from 2002

through 2005. The Office of Statistics organized a panel to improve the reliability of UCOD assignment between coders, and did not respond to the queried cases until 2004, when the official coders then changed half of the original UCOD assignments in the queried cases. The change rate decreased to 12% in 2005 because the coders had by then changed their habits with regard to assigning TB-related UCOD.

Reference for assessment

The reference (gold standard) we used to assess the accuracy of TB-related UCOD assignment by official coders was the UCOD assigned by the Automated Classification of Medical Entities (ACME) computer program. ACME was developed by the National Center for Health Statistics of the United States to standardize the processes of UCOD assignment. ACME is now used by more than 20 countries and was introduced to Taiwan in 2000.¹⁷

To prepare for the implementation of the ICD-10 version for cause of death statistics, the Office of Statistics initiated a double coding system in 2001. Each death certificate was assigned the ICD-9 UCOD code manually by official coders and the ICD-10 UCOD code by ACME, which provided us with a good opportunity to assess the quality of UCOD assignment of official coders from 2001 through 2005.

Analysis

All the death certificates of people who died between 2001 and 2005 on which TB was assigned as the UCOD either by official coders (ICD-9 codes 010–018) or by ACME (ICD-10 codes A16–A19) were included in this study. We first calculated the age-standardized death rates and age-specific death rates for TB according to the UCOD assigned by official coders and by ACME. The 95% confidence intervals (CI) for death rates were also computed to examine the differences between the official coders and ACME.

Using the UCOD assigned by ACME as the reference (gold standard), we calculated the rates of agreement, over-coding and under-coding by

Table 1. 2 by 2 table

UCOD assigned by official coders	UCOD assigned by ACME	
	Tuberculosis	Non-tuberculosis
Tuberculosis	a	c
Non-tuberculosis	b	d

Agreement rate = $a/(a+b+c)$

Over-coding rate = $c/(a+b+c)$

Under-coding rate = $b/(a+b)$

year, by sex and by age group for analyses. Because of the extremely large number of deaths in cell d in the 2 by 2 table (more than 130,000 deaths in this study), we did not include the number in cell d in the denominator when calculating the agreement rate and over-coding rate as suggested by Gordis¹⁸ (Table 1).

Results

TB death rates decreased from 2001 to 2005 according to both official coders and ACME. An abrupt decrease in TB death rates according to the UCOD assigned by official coders was noted from 2003 to 2004, but no such change was found according to the UCOD assigned by the reference (Figure). The difference in age-standardized TB death rate between coders and ACME was significant only in 2003 and mainly among the deceased aged ≥ 75 years (Table 2). We also found that the differences in TB death rates increased with increasing age of the deceased.

The agreement in TB-related UCOD assignment between official coders and reference decreased from 0.75 in 2001 and 2002 to 0.67 in 2004 and 2005 (Table 3). We found a significant decrease in the rate of over-coding from 2003 (0.21; 95% CI, 0.19–0.23) to 2004 (0.11; 95% CI, 0.10–0.13). However, a prominent increase in the rate of under-coding was noted from 2003 (0.08; 95% CI, 0.06–0.10) to 2004 (0.24; 95% CI, 0.21–0.26). The pattern of changes did not differ significantly by sex and age group (data not shown).

The diagnosis that most often replaced TB as the UCOD (under-coding) by official coders was

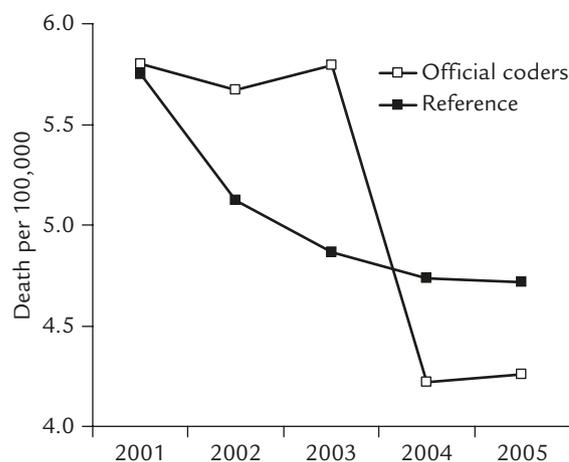


Figure. Estimated tuberculosis death rates according to the underlying cause of death assigned by official coders and by the ACME computer system (reference) in Taiwan, 2001–2005.

pneumonia, followed by diabetes mellitus and liver cirrhosis. On the other hand, the diagnosis that was most often replaced by TB as the UCOD (over-coding) by official coders was old TB followed by sepsis and chronic obstructive pulmonary disease (Table 4).

Discussion

Using the UCOD assigned by ACME as the reference (gold standard), our findings indicated that the abrupt decrease in the official published TB mortality rate from 2003 to 2004 was due to significant changes in the practices of UCOD assignment of official coders. In 2003 and before, a relatively high percentage of over-coding of TB as the UCOD by official coders was noted. On the contrary, a relatively high percentage of under-coding of TB as the UCOD by official coders was noted from 2004 onwards. The official published TB mortality rates are the result of net compensatory effects between over-coding and under-coding of TB by official coders.

Strengths and limitations

One of the strengths of this study was the population-based design with 5 years of comparisons between official coders and the reference.

Table 2. Age-standardized death rate (ASDR) and age-specific death rate and 95% confidence intervals (CI) for tuberculosis according to the underlying cause of death assigned by official coders or by the ACME computer system (reference) in Taiwan, 2001–2005

	2001	2002	2003	2004	2005
ASDR					
Coders (95% CI)	5.80 (5.48–6.11)	5.67 (5.36–5.98)	5.79 (5.48–6.10)	4.22 (3.95–4.49)	4.26 (3.99–4.53)
Reference (95% CI)	5.75 (5.43–6.06)	5.12 (4.83–5.42)	4.86 (4.57–5.15)	4.73 (4.45–5.02)	4.72 (4.43–5.00)
≤44					
Coders (95% CI)	0.52 (0.40–0.63)	0.36 (0.27–0.45)	0.47 (0.37–0.58)	0.32 (0.23–0.41)	0.26 (0.17–0.34)
Reference (95% CI)	0.60 (0.48–0.72)	0.34 (0.25–0.43)	0.42 (0.31–0.52)	0.34 (0.25–0.43)	0.35 (0.26–0.45)
45–64					
Coders (95% CI)	4.71 (4.08–5.35)	4.16 (3.57–4.74)	4.18 (3.61–4.76)	3.00 (2.52–3.47)	2.72 (2.27–3.16)
Reference (95% CI)	4.98 (4.33–5.63)	3.99 (3.41–4.56)	3.65 (3.11–4.18)	3.39 (2.88–3.90)	3.10 (2.62–3.57)
65–74					
Coders (95% CI)	25.01 (22.24–27.79)	24.14 (21.43–26.86)	22.96 (20.33–25.60)	15.75 (13.58–17.92)	13.44 (11.45–15.44)
Reference (95% CI)	23.97 (21.25–26.69)	22.55 (19.93–25.18)	18.62 (16.25–21.00)	17.31 (15.03–19.59)	16.29 (14.10–18.48)
≥75					
Coders (95% CI)	95.32 (88.22–102.42)	93.38 (86.57–100.19)	90.18 (83.69–96.68)	63.83 (58.52–69.14)	66.98 (61.68–72.28)
Reference (95% CI)	92.15 (85.17–99.13)	81.46 (75.10–87.83)	75.56 (69.61–81.50)	72.24 (66.59–77.89)	70.48 (65.04–75.91)

Table 3. Number of deaths where tuberculosis (TB) was assigned as the underlying cause of death (UCOD) either by official coders or by the ACME computer system (reference) and indicators of quality of UCOD assignment in Taiwan, 2001–2005

Coders	TB	Non-TB	TB	Agreement (95% CI)	Over-coding (95% CI)	Under-coding (95% CI)
Reference	TB	TB	Non-TB			
	a	b	c	a/(a+b+c)	c/(a+b+c)	b/(a+b)
Total						
2001	1109	179	190	0.75 (0.73–0.77)	0.13 (0.11–0.15)	0.14 (0.12–0.16)
2002	1038	116	239	0.75 (0.72–0.77)	0.17 (0.15–0.19)	0.10 (0.08–0.12)
2003	1012	87	297	0.72 (0.70–0.75)	0.21 (0.19–0.23)	0.08 (0.06–0.10)
2004	818	256	139	0.67 (0.65–0.70)	0.11 (0.10–0.13)	0.24 (0.21–0.26)
2005	823	251	147	0.67 (0.65–0.70)	0.12 (0.10–0.14)	0.23 (0.21–0.26)

Most previous studies used only sampled cases and were cross-sectional.^{19–21} In addition, many studies used the UCOD assigned by senior coders as the reference, which still has problems of reliability.^{19–21} Another strength of this study was the use of UCOD assigned by ACME as the reference, which was more objective and robust.^{16,17}

One of the limitations of this study was that we did not interview the official coders to determine their logic behind changing their coding practices from 2003 to 2004. The official coders might have had other information provided on the death certificate that was not accessed by ACME. In addition, the information input to ACME might

Table 4. Diagnoses that most often replaced tuberculosis (under-coding) or that were replaced by tuberculosis (over-coding) as the underlying cause of death by official coders in Taiwan, 2001–2005

Diagnosis that replaced tuberculosis	n (%)	Diagnosis replaced by tuberculosis	n (%)
Pneumonia	105 (11.8)	Old tuberculosis	168 (16.6)
Diabetes mellitus	93 (10.5)	Sepsis	122 (12.1)
Liver cirrhosis	73 (8.2)	Chronic obstructive pulmonary disease	103 (10.2)
Chronic obstructive pulmonary disease	42 (4.7)	Acute myocardial infarction	49 (4.8)
Old stroke	31 (3.5)	Cerebral infarction	42 (4.2)
Lung cancer	30 (3.4)	Heart failure	35 (3.5)
Stroke	29 (3.3)	Diabetes mellitus	31 (3.1)
Chronic renal failure	23 (2.6)	Urinary tract infection	25 (2.5)
Bronchiectasis	22 (2.5)	Stroke	24 (2.4)
Others	441 (49.6)	Others	413 (40.8)
Total	889 (100.0)	Total	1012 (100.0)

have sustained typos and coding errors, as found in a previous study.¹⁶

Why over-coding?

Many “old” TB cases were over-coded by official coders and TB assigned as the UCOD. As indicated in Table 3, there were 168 deaths assigned as old TB by ACME, which were coded as “active” TB by official coders. The reason for the discrepancy was that some of the official coders did not take into account the length of time between diagnosis and death that was reported by physicians. All deaths with duration of time between diagnosis and death that was longer than 1 year were classified by ACME as old TB.

The second reason for over-coding of TB as the UCOD by official coders was the reluctance in accepting mechanisms of death (i.e. sepsis, heart failure, respiratory failure, arrhythmia, and many ill-defined symptoms and signs) as the UCOD. Because the mechanisms of death were terminal events of the deaths which could not provide useful information for disease prevention, guidelines suggest that physicians should not report a mechanism of death without a specific cause of death.^{2,3} In many cases of over-coding, the physicians had reported sepsis or respiratory failure in Part I of the death certificate and reported TB in Part II of the death certificate, and the official coder then assigned TB as the UCOD according to the International Selection Rule 3 set by the

World Health Organization.¹ Variations in the interpretation of Selection Rule 3 comprised the main reason for the discrepancy in UCOD assignments across countries.^{19–21}

Why under-coding?

The main reason for under-coding of TB as the UCOD by official coders since 2004 might be the reactionary responses to the aggressive queries from the CDC. The CDC checked only those death certificates “with” tuberculosis assigned as the UCOD by official coders and did not check death certificates of notified TB cases “without” reporting TB as the UCOD. The biased selection for assessment would certainly result in under-coding of TB by official coders.

The second reason for under-coding of TB as the UCOD by official coders since 2004 was the changes in the International UCOD Selection Rule 3 in ICD-10 which was used by ACME. The most affected diagnosis was pneumonia as indicated in Table 2 and in other countries.^{22–24} For many cases with pneumonia reported in Part I of the death certificate and TB in Part II of the death certificate, the UCOD would be pneumonia according to Selection Rule 3 in ICD-9 and the UCOD would be TB according to Selection Rule 3 in ICD-10.

Policy implications

As mortality data are the most commonly used information in identifying health problems and

evaluating healthcare and disease control programs, the quality of mortality data should be ensured. Our findings indicate that the interpretation of changes in TB mortality from 2003 to 2004 in Taiwan should be cautious. The TB death rates calculated according to the UCOD assigned by ACME would be a better estimation of real epidemiological profiles. The Office of Statistics has scheduled to use ICD-10 and UCOD according to ACME for the official published cause of death statistics in 2008. We believe that the quality of UCOD assignment will be improved in the near future.

With regard to the reactionary responses of official coders from over-coding bias to under-coding bias in face of the CDC interventions, the Office of Statistics should provide more systematic education and training programs for better assignment of UCOD. As indicated by a previous study, the logic in ACME could be used as a teaching aid to train coders on how to correctly assign UCOD.¹⁷

If the CDC plans to continually assess the quality of TB-related UCOD assignment, we suggest that the death certificates of notified TB cases on which official coders did not assign TB as the UCOD should also be sampled to estimate the extent of under-coding bias.

To re-stress then, if physicians can report an appropriate cause of death, i.e. correct causal relationships between diseases on death certificates, then UCOD assignment can be very straightforward and simple. Both the CDC and the Office of Statistics should educate and urge physicians to correctly report the cause of death on death certificates, which is the most important determinant of the quality of cause of death statistics.

In conclusion, the abrupt decrease in official published TB mortality rates from 2003 to 2004 was due to significant changes in the practices of UCOD assignment of official coders, which might have been their response to the interventions initiated by the CDC. The over-coding and under-coding of TB death remains a problem in Taiwan. Using ACME to improve the quality of UCOD assignment is warranted.

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