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Journal of Clinical Epidemiology 54 (2001) 232–238

Journal of Clinical Epidemiology

Factors associated with errors in death certificate completion: A national study in Taiwan

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Received 30 November 1998; received in revised form 22 April 2000; accepted 2 May 2000

Abstract

To identify characteristics of certifying physicians and the deceased that are associated with errors in death certificate completion in Taiwan, we retrospectively reviewed 4123 systematically sampled death certificates issued in 1994. Multivariate analyses were used to assess the associations of various characteristics of the certifying physicians and the deceased with four types of error. Of the 4123 death certificates reviewed, 2525 (61%) were completed correctly. In 289 (7%), only the mechanism(s) of death was given (Major Error 1); in 146 (4%), multiple causal sequences were given in part I (Major Error 2); in 800 (19%), a single causal sequence was given but was not specific enough (Minor Error 1); and in 363 (9%), a single causal sequence was given but the order was incorrect (Minor Error 2). Multiple logistic regression analyses revealed that the probability of error in death certification increased as the age of the deceased increased, the age of the certifier decreased, and the level of the hospital decreased. These findings suggest that training in death certificate completion should focus on younger certifiers and those working at lower level teaching hospitals and nonteaching hospitals. Given the high rate of Minor Error 1, physicians should be reminded to state information as specifically as possible to render cause-of-death statistics more informative.

Keywords: Death certificate; Cause-of-death; International Classification of Disease; Certification; Accuracy; Epidemiology

1. Introduction

Cause-of-death statistics derived from death certificates are an important tool for health planning and epidemiologic studies. To ensure valid comparisons within and among countries, the World Health Organization (WHO) has recommended a standard cause-of-death diagnosis form to be used on death certificates [1]. Failure to follow the requirements of the standard form would be expected to adversely affect the accuracy and usefulness of cause-of-death statistics.

Many instruction handbooks and articles are available to teach physicians how to complete death certificates correctly [2–8]. Nevertheless, previous studies showed that the error rates in death certification completion are still very high, ranging from 25% to 78% in hospital-based studies [9–15], and from 16% to 56% in population-based studies [16–18]. The reasons behind these high error rates, however, remain obscure.

Only five of the above studies investigated factors affecting the likelihood of errors [12,14,16–18]. Most of these studies assessed only one factor (i.e., the type of doctor) and found that general practitioners made fewer errors than hospital doctors [12,17,18]. Two studies evaluated more than one factor, but did not use a multivariate analysis technique [14,16]. One of these, a hospital-based study in Taiwan revealed that the age of the deceased and the seniority and specialty of the certifying physician were significantly related to the error rate [14]. In a population-based study in Western Australia, the error rate did not vary significantly between city and county areas, or between teaching hospitals and other locations [16].

Without knowing the factors that affect error rates in death certificate completion, it is hard to design a relevant intervention program to improve the quality of death certification. Thus, we performed a national population-based study to determine the frequencies of various types of error in death certificate completion in Taiwan and to identify characteristics of the certifying physicians and the deceased that are associated with these errors.

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0895-4356/01/$ – see front matter
PII: S0895-4356(00)00299-7

This study was part of a project evaluating the quality of cause-of-death statistics in Taiwan. In the first phase of the project, we examined the accuracy of coding and selection of the underlying cause of death by coders and their effects on national mortality, as reported earlier [19]. The present study used the same data set as our previous investigation, but focused on the manner in which the specificity and the sequence of morbid events is reported on the medical certificate by certifying physicians.

2. Methods

All original death certificates in Taiwan are centralized to the Provincial department of Health, Office of Statistics. In 1994, 112,238 death certificates were issued. Systematic sampling (one in every 20) of these yielded 5621 death certificates. After excluding 1498 in which the underlying cause-of-death was not natural or the name and license number of the certifying physician could not be identified, 4123 death certificates were left for analysis.

Two authors (T.H.L. and C.K.L.) independently reviewed all the death certificates to determine the type of error on each. The two authors classified the type of error differently on four death certificates, and reached a consensus on these after discussion.

2.1. Types of error

We did not intent to validate the accuracy of the cause-of-death diagnoses; that is, we did not review the medical records or autopsy information. We examined only the wording and statements on the death certificate and determined whether the underlying cause-of-death was listed in an acceptable manner.

Previous studies have used various schemes to classify errors in death certificate completion. In this study, we modified the classification system described by Leadbeatter [9]. According to the level of confusion in selection of the underlying cause-of-death, the errors can be classified as Major Errors and Minor Errors (Table 1). Briefly, there were four types of error:

- Major Error 1: only the mechanism(s) of death (or mode of dying) is given. Because there could be hundreds of different causes leading to the same mechanism of death, this kind of description provides no useful information for cause-of-death statistics [5].
- Major Error 2: multiple causal sequences are given in part I. Standard form [1] indicates that the different causes-of-death should all be listed in Part I of the death certificate and should be in the sequence of events leading to death. The judgement of correct causal sequence was based on *ACME (Automated Classification of Medical Entities) Decision Tables* [20].
- Minor Error 1: a single causal sequence is given but is not specific enough. Examples, as listed in Table 1, include listing tumor without specifying the malignancy; listing cancer without specifying the primary site; listing stroke or cerebrovascular accident (CVA) without specifying the subtype; listing gastrointestinal bleeding without specifying the location; and listing traffic accident without specifying type of vehicle(s) involved. The level of 'specificity' required depends on the level of availability of information for making specific diagnosis; thus, different areas use different levels of priority in querying nonspecific death certificates [21,22]. Because computed tomography is very commonly used in Taiwan, stroke can generally be specified as being due to either cerebral infarction or cerebral hemorrhage. To make cause-of-death statistics more informative, the registers in the Office of Statistics, Taiwan Provincial Department of Health, query death

Table 1
Examples of types of error in death certificate completion

Major error 1: only mechanism(s) of death given	Major Error 2: multiple causal sequences given in part I	Minor error 1: single causal sequence given but not specific enough	Minor error 2: single causal sequence given but the order was incorrect
a: cardiopulmonary failure	a: pneumonia	a: stroke	a: liver cirrhosis
b:	b. diabetes	b.	b. hepatoma
c:	c: emphysema	c:	c: rupture of esophageal varices
a: cardiac arrest	a: ventricular hemorrhage	a: malignant tumor	a: diabetes
b: arrhythmia	b: congenital heart disease	b:	b: ischemic heart disease
c:	c: pneumonia	c:	c: sepsis
a: respiratory failure	a: polycystic kidney disease	a: acute renal failure	a: cardiopulmonary failure
b: sepsis	b: acute myocardial infarction	b: shock	b: hepatectomy due to hepatoma
c:	c: duodenal ulcer with bleeding	c: upper gastrointestinal bleeding	c: sepsis
a: acute renal failure	a: pulmonary edema	a: traffic accident	a: pulmonary failure
b: shock	b: tuberculous pneumonia	b:	b:
c: dehydration	c: cerebrovascular accident	c:	c:
			II: lung cancer

Note: The international form of medical certificates of cause-of-death recommended by the World Health Organization includes Part I and Part II. Part I includes lines a, b, and c for entering the sequence of events leading to death, proceeding backwards from the direct cause-of-death on line a. Part II is for other significant contributory conditions.

certificates listing 'stroke' as the underlying cause-of-death for more specific diagnosis [23].

- Minor Error 2: a single causal sequence is given but the order was incorrect. This type of error has no significant impact on the quality of cause-of-death statistics, because the underlying cause-of-death can still be correctly determined.

2.2. Associated factors

The name and license number of the certifying physician on the death certificate were used to obtain information, from the *Directory of Physicians in Taiwan* [24], on their age, specialty, training background, and setting of practice. Physicians were classified according to their specialty as general practitioners, internists (including internal medicine, pediatrics, dermatology, and psychiatry) or surgeons (including general surgery, orthopedics, urology, obstetrics and gynecology, ophthalmology, and otorhinolaryngology).

After the end of World War II, General Chiang-Kai-Shek withdrew his forces from mainland China to Taiwan together with about 2 million followers. Most of the military-trained doctors passed a special examination to obtain a license [25]. Thus, we classified the medical training backgrounds of physicians as Grade-A (graduated from medical school) or Grade-B (preceptor-trained, 2-years-short-trained, or military-trained) [25].

The setting of practice was classified into five categories: tier 1 hospitals (medical centers teaching hospitals), tier 2 hospitals (regional teaching hospitals), tier 3 hospitals (district teaching hospitals), tier 4 hospitals (nonteaching hospitals), and clinics [26]. The demographic data (sex and age) of the deceased were abstracted from the death certificates.

2.3. Statistical analysis

Multiple logistic regression was used to analyze the association between various factors and types of error. Age of physicians (by 5-year intervals) and age of the deceased (by 10-year intervals) were treated as ordinal variables in the multiple logistic regression analysis. The setting of practice was treated as a nested variable. The level of hospital (4 tiers) was nested in the dichotomized variable (hospital vs. clinic). To simplify the analyses of associations between various factors and different types of error, the errors were combined as outcomes according to the level of confusion in the selection of underlying cause-of-death. Thus, Major Error 1 and Major Error 2 were combined as Major Error; and Minor Error 1 and Minor Error 2 were combined as Minor Error.

Interaction effects were studied according to hierarchic order model fitting, and were examined by the likelihood ratio test. When the higher order interaction terms were significant, all of the lower order terms were also included in the model regardless of the *P* values. The whole set of categoric independent variables ('setting of practice'or 'specialty') was selected for inclusion in the model according to the all-or-none rule [27]. The processes of the interaction effects tests are shown in the Appendix. The adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to measure the associations between selected characteristics and the probabilities of errors.

3. Results

3.1. Frequencies of errors

Of the 4123 death certificates reviewed in this study, 2525 (61%) were completed correctly. In 289 (7%), only the mechanism(s) of death was given (Major Error 1); in 146 (4%), multiple causal sequences were given (Major Error 2); in 800 (19%), a single causal sequence was given but was not specific enough (Minor Error 1); and in 363 (9%), a single causal sequence was given but the order was incorrect (Minor Error 2).

3.2. Factors associated with errors

The rates of the various types of error according to the characteristics of the deceased and the certifying physician are shown in Table 2. For all types of error combined, the error rates increased as the age of the deceased increased, the age of the certifier decreased, and the level of hospital decreased. Younger certifiers and Grade-A physicians were more likely than their counterparts to commit a Major Error. The lower the level of the hospital, the higher the probability of committing a Minor Error.

The age of the deceased, the age of the certifier, the specialty of the physician, and the setting of practice were included in the multiple logistic regression models. Generally, the probability of 'All Errors' increased as the age of the deceased increased, the age of the certifier decreased, and the level of the hospital decreased (Table 3). The age of the certifier and the training background were the two most significant predictors of Major Errors. The level of the hospital was an important predictor of Minor Errors.

Some of the characteristics showed interactive effects on the probability of error in death certification (Table 3). The odds of Grade-A physicians (compared with Grade-B physicians) committing All Errors ($P < .001$) increased from 0.55 (95% CI 0.25–1.20) to 0.76 (95% CI 0.65–0.87) when completing death certificates for elderly deceased. In the main effect model, the odds of internists (compared with general practitioners) committing a Minor Error increased from 0.96 (95% CI 0.71–1.32) ($P < .001$) to 1.34 (95% CI 1.14–1.58) when completing death certificates for elderly deceased.

4. Discussion

In this national population-based study, one third of the death certificates issued in 1994 were completed incorrectly. The most frequent type of error was Minor Error 1

Table 2
Distribution of error rates (%) in death certificate completion by types of error and characteristics of the deceased and certifying physicians

Characteristic	No.	Major Error 1 (%)	Major Error 2 (%)	Minor Error 1 (%)	Minor Error 2 (%)	Major Error 1,2 (%)	Minor Error 1,2 (%)	All Error (%)
Total	4123	7	4	19	9	11	28	39
Sex of the deceased								
Male	2405	7	4	20	9	11	29	40
Female	1718	8	3	19	8	11	27	38
Age of the deceased								
59 or below	935	6	3	12	11	9	23	32
60–69	918	6	3	18	9	9	27	36
70–79	1274	7	5	21	8	12	29	41
80 or above	996	9	3	26	8	12	34	46
Age of certifier								
34 or less	957	9	3	16	10	12	26	38
35–39	745	10	4	18	8	14	26	40
40–44	607	5	3	20	8	8	28	36
45–54	701	7	3	22	7	10	29	39
55 or above	1113	5	4	21	11	9	32	41
Training background								
Grade-A (medical school)	3301	7	4	20	8	11	27	38
Grade-B (military-trained)	822	5	4	21	12	9	33	42
Specialty								
General practitioner	1434	7	3	20	6	10	26	36
Internist	1405	6	4	18	10	10	28	38
Surgeon	1284	7	3	20	11	11	31	42
Setting of practice								
Tier 1 teaching hospital	585	7	2	13	9	9	22	31
Tier 2 teaching hospital	662	6	5	16	13	11	29	40
Tier 3 teaching hospital	391	7	6	19	10	13	29	42
Nonteaching hospital	520	8	3	29	8	11	37	48
Clinic or health station	1965	7	3	20	7	10	27	37

(19%). Important factors associated with the error rates were the age of the deceased, the age of the certifier, and the level of the hospital.

4.1. Major Error 1

Although previous studies did not classify the types of error according to a consistent theme, most included an error category of ‘only mechanism(s) of death.’ The rate of Major Error 1 in our study was 7%, which is relatively low compared with previous studies in Wales (14%) [9], Cincinnati (29%) [10], Ontario (10%) [12], Rotherham (21%) [13], Taichung (10%) [14], and Ontario (16%) [15].

Why do certifying physicians often write only the mechanism(s) of death? As Kircher stated, most physicians tend to confuse the cause-of-death with the mechanism of death [5]. The cause-of-death is a distinct entity, and is etiologically specific. Examples include lung cancer, diabetes mellitus, and alcoholic liver cirrhosis. The mechanism of death, on the other hand, is a physiologic derangement or a biochemical disturbance produced by a cause-of-death. Examples include various arrhythmias, renal failure, cardiopulmonary failure, sepsis, and hypovolemic shock. One reason for this confusion may be that medical therapy is often aimed at modifying or ameliorating mechanisms rather than causes, thereby focusing attention on the former to the exclusion of the latter [5].

Because of their lack of etiologic specificity, mechanisms of death should not appear on death certificates [2–8]. Nevertheless, in daily clinical practice, a definite cause-of-death is not always identified. It is also common for dying patients to be sent to hospitals (especially teaching hospitals) without any accompanying background information, and in these cases the mechanism(s) of death might be the only choice. Thus, Hanzlick proposed some principles for including or excluding mechanisms of death when writing the cause-of-death statement [28].

4.2. Major Error 2

According to the study of Lu et al. [14], in most death certificates with Major Error 2 the certifying physician copied the admission or discharge diagnoses directly to the cause-of-death section on the death certificate. The listing orders of the admission diagnoses are according to the ‘principle of severity’ and main reason for admission; nevertheless, the listing orders of cause-of-death diagnoses are according to the ‘principle of causality.’ If the certifying physician copies the admission or discharge diagnoses directly to the cause-of-death section on the death certificate, there will be many diagnoses listed without causal relationships. Take, for example, a patient admitted to the hospital mainly for complications of diabetes, but who also had emphysema. The first admission diagnosis would be diabetes

Table 3
Results of logistic regression model predicting the likelihood of error in death certificate completion by types of error and characteristics of the deceased and certifying physicians

	Major Error 1, 2	Minor Error, 1, 2	All Error
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Main effects			
Training (Grade-A/Grade-B)	1.83 (1.18–2.84)**	0.43 (0.17–1.06)	0.55 (0.25–1.20)
Age of certifier (reference: 34 or below)[a]	0.71 (0.62–0.82)***	1.09 (0.97–1.23)	0.93 (0.88–0.99)*
Age of deceased (reference: 59 or below)[b]	1.09 (0.94–1.26)	1.04 (0.93–1.16)	1.28 (1.20–1.37)***
Setting of practice (hospital/clinic)	0.92 (0.58–1.44)	0.94 (0.69–1.29)	0.97 (0.74–1.28)
Hospital level (reference: tier 1 hospital)	1.14 (0.97–1.33)	1.29 (1.17–1.41)***	1.25 (1.15–1.36)***
Specialty 1 (internist/general practitioner)	1.10 (0.74–1.64)	0.96 (0.71–1.32)	0.96 (0.74–1.26)
Specialty 2 (surgeon/general practitioner)	1.29 (0.91–1.82)	1.05 (0.79–1.38)	1.06 (0.83–1.36)
Two-way interaction			
Training × age of certifier		1.75 (1.07–2.86)*	1.72 (1.13–2.63)*
Training × age of deceased			0.76 (0.65–0.87)***
Training × specialty 1		0.76 (0.26–2.25)	0.96 (0.41–2.23)
Training × specialty 2		2.20 (1.28–3.77)**	1.57 (1.03–2.41)*
Age of certifier × age of deceased	0.92 (0.84–1.01)		
Age of certifier × setting of practice	1.36 (1.06–.174)*		
Age of certifier × hospital level	1.00 (0.91–1.11)		
Age of deceased × setting of practice	1.43 (1.02–2.02)*		
Age of deceased × hospital level	1.00 (0.87–1.15)		
Age of certifier × specialty 1		0.84 (0.72–0.99)*	
Age of certifier × specialty 2		0.87 (0.74–1.03)	
Age of deceased × specialty 1		1.34 (1.14–1.58)***	
Age of deceased × specialty 2		1.18 (1.01–1.39)*	
Three-way interaction			
Age of certifier × age of deceased × setting of practice	1.30 (1.06–1.59)*		
Age of certifier × age of deceased × hospital level	0.90 (0.82–0.99)*		

[a]Odds ratio is for an increase of 5 years.
[b]Odds ratio is for an increase of 10 years.
*$P<0.05$, **$P<0.01$, ***$P< 0.001$.

and the second would be emphysema, according to the severity of the problems. If the certifying physician entered diabetes on the first line of the death certificate and emphysema on the second, the certificate would have a Major Error 2 because it would suggest that emphysema was the cause of diabetes.

4.3. Minor Error 1

In terms of the health policy impacts of the different types of error in cause-of-death statistics (i.e., whether they change the ranking of the leading causes-of-death), Major Error 1 has the greatest impact, followed by Major Error 2. Minor Error 1 will not change the ranking of the leading causes-of-death if the two-digit codes of the International Classification of Diseases, 9th revision (ICD-9) [1] are used. For example, the three-digit ICD-9 code is 434 for cerebral infarction and 431 for cerebral hemorrhage; however, both causes-of-death have the same two-digit ICD-9 code: 29. Almost one fifth of the death certificates in our study contained a Minor Error 1. If more specific information had been given on these death certificates, the death rates according to three-digit codes might have been significantly different.

Another common example of Minor Error 1 is the unspecific diagnosis of ‘tumor’ or ‘cancer.’ As the National Center for Health Statistics, ‘always query neoplasms for a primary site and/or histologic type when not reported’ [21]. Most epidemiologic studies using cause-of-death data required at least three-digit code classification, and some even required four-digit code classification. Certifying physicians should be trained to enter the cause-of-death diagnosis as specifically as possible.

4.4. Minor Error 2

There are footnotes in the cause-of-death section of the standard form of the death certificate to remind the certifying physician that the causal sequence is disease “a” due to disease “b”; and disease “b” due to disease “c” [3]. Nevertheless, the rates of Minor Error 2 (the order of causal sequence was incorrect) are still high in many countries: 5% in Wales [9], 30% in Cincinnati [10], 38% in Colombo [11], 22% in Ontario [12], 15% in Taichung [14], and 9% in the present study. Fortunately, death certificates with this type of error contain sufficient information for accurate coding, and would not affect subsequent epidemiologic studies.

4.5. Associated factors

The most significant factor associated with the error rates was the age of the deceased. The likelihood of comorbid conditions increases with advancing age, making it more difficult for the certifying physician to establish a single causal sequence. This is why many scholars criticize the

concept of underlying cause-of-death and suggest using multiple causes-of-death [29–31].

The age of the certifiers was the most important predictor of Major Error. This might have resulted from a lesser emphasis given to younger physicians in the teaching and training of how to correctly complete death certificates. Previous studies also reported that different generations of physicians have different preferences in selecting terms when making the cause-of-death diagnosis [32–34]. However, James and Bull argued that seniority is not a good predictor of better performance in death certificate completion [35].

The level of teaching hospital also affected the likelihood All Error and Minor Error. This might suggest that requirements and standards of training in death certificate completion vary among hospital levels. Nevertheless, certifiers who practiced in clinics did not have higher error rates than their counterparts in hospitals. This might be because of the simplicity of cases encountered in clinics.

Previous studies [12,17,18] indicated that general practitioners perform better in death certification than specialists. This might be because of the greater familiarity of general practitioners with their patients. In the present study, specialty was significantly associated with the likelihood of Minor Error only in the interaction terms. In most cases of Minor Error on death certificates of elderly deceased, internists listed ‘stroke’ or ‘CVA’ as the diagnosis while surgeons listed ‘trauma’ without specifying external causes. These findings highlight areas of focus for future education and training.

4.6. Limitations and conclusions

This study did not review medical records or autopsy information to validate the accuracy of the cause-of-death diagnoses. Rather, only the wording and statements on the death certificate were examined, to determine whether the underlying cause-of-death was listed in an acceptable manner. We believe that this is the basic requirement for death certificate completion.

We analyzed only the characteristics of the deceased and the physicians, and did not assess the logic behind every episode of death certificate completion. To address this issue, a more intensive, qualitative, interview-based study on the logic of death certification is needed.

Differences in the definitions and interpretations of error types make between-study comparisons difficult. For example, the category of ‘mechanism(s) only’ may be interpreted differently in various studies: cardiac and renal failure might be treated as mechanisms of death in some studies, while in others they might be accepted as causes-of-death.

Maudsley and Williams [36] indicated that certifiers are receptive to more education about death certification, but it is not yet known which interventions are best. We do believe that information on errors in death certificate completion is of paramount importance for designing relevant training programs for medical students and residents.

Our findings indicate that the age of the deceased, the age of the certifier, and the level of hospital were the most significant predictors of errors in death certification. Therefore, training in death certificate completion should focus on younger certifiers and lower level teaching hospitals and nonteaching hospitals. Given the high rate of Minor Error 1, physicians should be reminded to state information as specifically as possible to render cause-of-death statistics more informative.

Acknowledgments

This study was supported by the Department of Health, Republic of China (DOH85-TD-042). The authors wish to thank Show-Ru Shau for assisting with the data management and Jeff Radcliff for English revision of this manuscript.

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Appendix

Tests of interaction effects by hierarchical order of model fitting and likelihood ratio tests

Outcome	Model	*n*	Residual *df*	Residual deviance	Change of *df*	Change of deviance	*P* value
Major Error 1, 2	Main effect[a] only	2960	2952	2431			
	+ 2 way interaction		2934	2396	18	34.40	.011
	+ all higher order interactions		2907	2343	27	53.50	.002
Minor Error 1, 2	Main effect only	3688	3680	4505			
	+ 2 way interaction		3662	4465	18	40.20	.002
	+ all higher order interactions		3634	4428	28	36.30	.134
All Error	Main effect only	4123	4115	5409			
	+ 2 way interaction		4097	5369	18	40.20	.002
	+ all higher order interactions		4069	5329	28	39.70	.070

[a]Main effect models include terms of physician training background ($df=1$), age of certifying physician ($df=1$), age of the deceased ($df=1$), setting of practice ($df = 2$), and specialty ($df = 2$).