

Diversity in death certification: A case vignette approach

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Abstract

Previous studies have revealed high rates of errors in death certification, but few have discussed the nature of these errors. To explore the diversity among physicians in death certification and its relationship with the complexity of the causal sequence of death, we asked 145 physicians attending a continuing medical education course to complete the cause-of-death section on dummy death certificates of four case vignettes. The difficulty in determining the causal sequence of death varied from relatively simple to complex. Variations in death certification were classified according to wording, diagnostic semantics, combinations of expressions, correctness of certification format, and concordance with the referent underlying cause of death (UCOD). Given the same case history information, physicians showed great variation in wording and diagnostic semantics in death certification. The rates of correct certification format and concordance with referent UCOD varied with the level of complexity of the causal sequence of death. The greatest source of diversity was choosing between an acute condition of a chronic disease and the chronic disease itself, and between competing prominent comorbidities. Experience in death certification was significantly associated with correct certification format but not with concordance with referent UCOD. Knowledge of death certification was not associated with correct certification format or concordance with referent UCOD. Our findings indicate that the traditional concept of UCOD tabulation and using a single standard ICD code in evaluating the quality of death certification oversimplifies a complex situation. Variations in death certification, especially the selection of UCOD, were due to differences in interpreting the information rather than differences in knowledge of death certification. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

Death certificates are the building blocks of cause-of-death statistics, which guide decisionmaking for allocation of medical resources. High-quality cause-of-death statistics are therefore essential to ensure that resources are used effectively. Although great effort has been devoted to teaching physicians how to fill out death certificates correctly [1–7], Maudsley and Williams' review showed high rates of errors and discrepancies between the original certifiers and evaluators in death certification worldwide [8]. Nevertheless, the nature of these errors has not been widely studied.

Most evaluations to date have defined "accurate" death certification according to a single standard, the International Classification of Disease (ICD) code. However, as Moriyama

suggested, when evaluating the quality of death certification we should consider not only the extent of disagreement, but also the level of agreement and the reasons for discrepancies [9].

The cause-of-death section of the death certificate is designed according to the concept of underlying cause of death (UCOD). To prevent death due to specific causes, it is necessary to break the chain of events or to effect a cure at some point. From this standpoint the most effective public health objective is to prevent the precipitating cause of death from operating. Therefore, the UCOD has been defined as "(a) the disease or injury which initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury" [10]. The medical practitioner signing the death certificate is responsible for indicating which morbid conditions led directly to death and stating any antecedent conditions giving rise to this cause [10]. Nevertheless, in everyday clinical situations, determining the causal sequence of death is not this simple.

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In this study, we looked at the nature of errors in death certificate completion. To explore the pattern of variation in death certification by level of complexity of the UCOD, we asked a group of physicians attending a continuing medical education course to complete the cause-of-death section on dummy death certificates of four case vignettes. We further explored the associations between the characteristics of the physicians (experience with and knowledge of death certification) and two important measures of certification quality: correct certification format and concordance with referent UCOD. Our objective was to determine if variations in certification among physicians are due to lack of knowledge, as many previous studies assumed, or to differences in interpreting the information and selecting the UCOD.

2. Methods

2.1. Case vignettes

The four case history vignettes used in this study were modified from the *Physicians' Handbook on Medical Certification of Death* [2]. The vignettes represented four levels of complexity in determining the UCOD: Case A, an acute condition without comorbidity; Case B, a chronic disease with multiple complications; Case C, an acute condition of one prominent chronic disease with two mild comorbidities; and Case 4, two competing prominent diseases.

2.1.1. History of Case A

Shortly after dinner on the day before admission to the hospital, this 48-year-old obese woman developed a cramping, epigastric pain that radiated to the back, followed by nausea and vomiting. The pain was not relieved by position or antacids. The pain persisted, and 24 hours after onset, the patient sought medical consultation. The patient was admitted to the hospital with a diagnosis of acute pancreatitis. Radiological findings included widening of the duodenal "C" loop and blurring of the left psoas muscle margin. Serum amylase was 1120 units per liter. The day after admission, the patient seemed to improve. However, that evening she became disoriented, restless, and hypotensive. Despite intravenous fluids and norepinephrine, the patient remained hypotensive and died 8 hours later.

Referent UCOD: acute pancreatitis.

2.1.2. History of Case B

A 78-year-old woman was admitted to the hospital from a nursing home because of a temperature of 102.6°F. She first became a resident of a nursing home 1 year earlier, after an intracerebral hemorrhage that left her with a residual left hemiparesis. She became increasingly dependent on others to help her with activities of daily living, and eventually required an indwelling Foley catheter 3 months before admission. For the 3 days before admission she was noted to have lost her appetite and to have become increasingly withdrawn. On admission to the hospital her leukocyte count was 19,700, she had pyuria, and gram-negative rods

were seen on a Gram stain of the urine. Ampicillin was administered intravenously. Blood cultures 2 days after admission were positive for *Pseudomonas aeruginosa*. Antibiotic therapy was changed to tobramycin and ticarcillin. Despite the antibiotics, intravenous fluid support, and steroids, the patient's fever persisted. On the fourth day after admission she became hypotensive and died.

Referent UCOD: intracerebral hemorrhage or cerebrovascular accident (CVA).

2.1.3. History of Case C

A 70-year-old woman had a 15-year history of non-insulin-dependent diabetes, a history of mild hypertension treated with thiazide diuretics, and an uncomplicated myocardial infarction 6 years before the present illness. She was found obtunded in her apartment and brought to the hospital. On admission she was noted to be unresponsive, without focal neurologic signs, and severely dehydrated with a blood pressure of 90/60. Initial laboratory tests disclosed severe hyperglycemia, hyperosmolarity, azotemia, and mild ketosis without acidosis. A diagnosis of hyperosmolar nonketotic coma was made. The patient was treated vigorously with fluids, electrolytes, insulin, and broad-spectrum antibiotics, although no source of infection was documented. Within 72 hours, the patient's hyperosmolar, hyperglycemic state was resolved. However, she remained anuric with progressive azotemia. Attempts at renal dialysis were unsuccessful, and the patient expired on the eighth hospital day in severe renal failure.

Referent UCOD: diabetes or diabetic coma or hyperglycemic hyperosmolar nonketoacidotic coma (HHNK)

2.1.4. History of Case D

This 82-year-old man was admitted to the hospital with chest pain. He had a past history of arteriosclerotic heart disease with coronary insufficiency and episodes of congestive heart failure controlled in the past by digitalis and diuretics. He also had an unexplained anemia that in the past had been attributed to thalassemia. Workup for anemia revealed an Hct of 17; the stool was positive for occult blood. A barium enema showed a polypoid lesion compatible with carcinoma of the cecum. Because of his heart problems it was felt that surgery was not indicated, and he was treated with a 5-week course of radiation therapy and periodic blood transfusions. Three months later he experienced chest pains and a probable acute myocardial infarction. He expired 2 days later.

Referent UCOD: acute myocardial infarction (AMI) or arteriosclerotic heart disease.

2.2. Participants

The participants were selected from 145 physicians attending a 1-day continuing medical education course held by Chung Shan Medical & Dental College Hospital, Taichung, Taiwan, on June 6, 1999. The course included six different topics, including "How to correctly write a death certificate." Before the lecture, the participating physicians

were asked to read the four vignettes and complete the cause-of-death section on the dummy death certificate for each. The absence of a “correct” diagnosis for each case was emphasized to the participants. Basic information on the physicians (age, gender, training background, type of practice) and their experience in death certification (how many death certificates issued during the past 6 months, having read instructions on death certificate completion, having been taught how to write a death certificate at school or in a hospital, and general knowledge of death certification) were also obtained with a 1-page questionnaire. General knowledge was defined according to the number of correct answers to seven questions regarding the instruction on correct death certification: good = five or more correct; fair = 3 or 4 correct; poor = fewer than 4 correct. The representativeness of the study sample was calculated by comparing the demographic characteristics of participating physicians with those of members of the Joint Medical Association of Republic of China in Central Taiwan [11].

2.3. Analysis

The completed death certificates were analyzed according to four levels of diversity: wording and diagnostic semantics, combinations of expressions, correct certification format, and concordance with referent UCOD.

2.3.1. Classification of diversity: wording and diagnostic semantics

Different expressions (wording) might indicate the same diagnostic semantic. For example, “urinary tract infection,” “UTI,” “infection of urinary tract,” and “urinary infection” all refer to the same diagnostic semantic, despite the differences in word choice.

2.3.2. Classification of diversity: combinations of expressions

Different expressions can be combined in many different formats. For example, “UTI” and “CVA” could be written in several different combinations in the cause-of-death section of the death certificate; their relative positions would affect the UCOD selection, as in the flowing examples:

- I. (a) CVA I. (a) UTI I. (a) CVA I. (a) UTI I. (a) CVA, UTI I. (a) UTI, CVA
- (b) UTI (b) (b) (b) CVA (b) (b)
- II. II. CVA II. UTI II. II. II.

The UCOD would be UTI for the first two examples, and CVA for the latter four examples.

2.3.3. Classification of diversity: correctness of certification format

The definition of incorrect certification format was modified according to previous studies [12–18]. If the physician wrote only the mechanism or mode of death (e.g., shock, sepsis, cardiopulmonary arrest, renal failure), or if the causal sequence was improbable or the layout order was reversed, the certification format was considered incorrect. The decision as to whether the causal sequence was improbable was based on the ACME (Automatic Classification of Medical Entry) decision table [19]. If the physician provided at least one cause of death, the causal sequence was considered acceptable; if the layout order followed the standard format (i.e., line “a” due to line “b,” and line “b” due to line “c”), the certification format was considered correct. Some examples of incorrect and correct certification format are illustrated in Table 1.

According to Rule 3, or Modification Rules, of WHO UCOD selection rules [10], some diagnoses in Part II of the cause-of-death section of the death certificate would be chosen

Table 1
Examples of correct and incorrect certification format and agreement with referent underlying cause of death (UCOD)

	Case A	Case B	Case C	Case D
Referent UCOD	Acute pancreatitis	Intracerebral hemorrhage or stroke	Diabetes or HHNK	AMI or CAD
Correct certification format with same UCOD	I. (a) Hypovolemic shock (b) Acute pancreatitis (c) II.	I. (a) UTI (b) Stroke (c) II.	I. (a) Diabetic coma (b) Diabetes (c) II.	I. (a) CHI (b) AMI II. Malignant tumor of the cecum
Incorrect certification format but same UCOD	I. (a) Acute pancreatitis (b) Shock (c) Cardiac failure II.	I. (a) ICH (b) UTI (c) Sepsis II.	I. (a) Acute renal failure (b) Diabetes (c) Hypertension II. CAD	I. (a) AMI (b) CHF (c) Cardiac arrest II.
Correct certification format but different UCOD	I. (a) Pancreatitis (b) Obesity (c) II.	I. (a) Bacteremia (b) UTI (c) II. Old CVA	I. (a) Renal failure (b) Coronary heart disease (c) Hypertension II. Diabetes	I. (a) Heart failure (b) Cancer of cecum (c) II.
Incorrect certification format and different UCOD	I. (a) Hypotensive shock (b) (c) II.	I. (a) Dysuria (b) Sepsis (c) II. Urinary catheter inserted	I. (a) Acute renal failure (b) Uremia (c) II. Diabetes	I. (a) GI malignancy (b) AMI (c) ASHD II. CHF

HHNK = hyperglycemic hyperosmolar nonketoacidotic coma; AMI = acute myocardial infarction; UTI = urinary tract infection; CHF = congestive heart failure; ICH = intracerebral hemorrhage; CAD = coronary arterial disease; GI = gastrointestinal; ASHD = arteriosclerotic heart disease

Table 2
Characteristics of participating physicians and their experience in and knowledge of death certification

	No.	%
Sex		
Male	122	98.6
Female	2	1.4
Age, years		
25–34	4	3.6
35–44	17	13.7
45–54	20	15.8
55–64	32	25.9
65 and above	51	41.0
Training background		
Medical school	62	50.0
Non-medical school	62	50.0
Type of practice		
Hospital	22	17.7
Clinic	102	82.3
Number of death certificates issued per month		
1 or none	74	59.7
2–3	37	29.8
4 and above	13	10.5
Have you ever read the instructions on how to write a death certificate?		
Yes	87	70.2
No	37	29.8
Have you ever been taught how to write a death certificate in school?		
Yes	44	64.5
No	80	35.5
Have you ever been taught how to write a death certificate in a hospital?		
Yes	62	50.0
No	62	50.0
Knowledge about cause of death certification, seven questions ^a		
Two or fewer questions correctly answered	17	14.3
Three or four questions correctly answered	80	67.2
Five or more questions correctly answered	22	18.5

^aOnly 119 physicians answered all seven questions.

as the UCOD. Therefore, we also examined differences in the presentations of diagnoses in Part II among participating physicians.

2.3.4. Classification of diversity: concordance with referent UCOD

To more accurately reflect the real situation in official cause-of-death statistics, we asked the official coder of the Taiwan Provincial Department of Health to select the UCOD of the completed dummy death certificates according to WHO selection rules. The UCOD of each dummy death certificate was compared with the referent UCOD at the three-digit ICD-9 code level. In some cases, the physician might use an incorrect certification format, but the coder could still select the referent UCOD by following the modified ICD selection rules [10]. Some examples are illustrated in Table 1.

2.3.5. Statistical analysis

Differences in the characteristics of the participating physicians and physicians of central Taiwan were tested by chi-square tests. Multiple logistic regression was used to an-

Table 3
Diversity in death certification for Case A vignette among 124 physicians

Classification	No.	%
Distinct expressions used	80	
Distinct diagnostic semantics	42	
Distinct combinations of expressions	80	
Certification format and agreement with referent underlying cause of death (UCOD)		
Correct certification format and same UCOD	87	70.2
Incorrect certification format but same UCOD	22	17.7
Correct certification format but different UCOD	5	4.0
Incorrect certification format and different UCOD	10	8.1
Stated UCOD		
Acute pancreatitis	109	87.9
Hypovolemic shock or shock	8	6.5
Obesity	4	3.2
Others	3	2.4
Total	124	100

Referent UCOD: acute pancreatitis.

alyze the associations between various factors (characteristics of physicians, experience and knowledge on death certification) and two important measures of certification quality: correct certification format and concordance with referent UCOD. The adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to measure the associations.

3. Results

Of the 145 physicians, 124 (85.5%) agreed to participate in the study; however, only 121 physicians filled out all four dummy death certificates. Comparison of the characteristics of participating physicians and general physicians in central Taiwan revealed that the study participants were older and more likely to have non-medical school training (i.e., they had received their medical training in the military).

Table 4
Diversity in death certification for Case B vignette among 121 physicians

Classification	No.	%
Distinct expressions used	79	
Distinct diagnostic semantics	36	
Distinct combinations of expressions	104	
Certification format and agreement with referent underlying cause of death (UCOD)		
Correct certification format and same UCOD	40	33.1
Incorrect certification format but same UCOD	9	7.4
Correct certification format but different UCOD	57	47.1
Incorrect certification format and different UCOD	15	12.4
Stated UCOD		
Intracerebral hemorrhage	20	16.5
Stroke or cerebrovascular accident (CVA)	29	24.0
Sequelae of cerebrovascular disease, old CVA	7	5.8
Urinary tract infection	38	31.4
Long-term insertion of catheter	10	8.3
Acute or chronic renal failure	8	6.6
Sepsis or bacteremia	5	4.1
Others	4	3.3
Total	121	100

Referent UCOD: intracerebral hemorrhage or CVA.

Table 5
Diversity in death certification for Case C vignette among 122 physicians

Classification	No.	%
Distinct expressions used	29	
Distinct diagnostic semantics	19	
Distinct combinations of expressions	84	
Certification format and agreement with referent underlying cause of death (UCOD)		
Correct certification format and same UCOD	82	67.2
Incorrect certification format but same UCOD	29	23.8
Correct certification format but different UCOD	4	3.3
Incorrect certification format and different UCOD	7	5.7
Underlying cause of death		
Diabetes	111	91.0
Coronary arterial disease	5	4.1
Acute renal failure or uremia	4	3.3
Others	2	1.6
Total	122	100

Referent UCOD: diabetes, diabetic coma, or hyperglycemic hyperosmolar nonketoadidotic coma (HHNK).

Table 2 shows the characteristics, including experience in and knowledge of death certification, of the 124 participating physicians. Three-fifths of the physicians had issued one or no death certificates per month during the last 6 months. Almost three-fourths of the physicians said that they had read instructions on death certificate completion. More than three-fifths of the physicians said that they had been taught how to write death certificates in school, while about half had received training in death certificate completion in a hospital. However, despite their training, their knowledge of death certification was not good: fewer than one-fifth of the physicians answered five or more questions correctly (Table 2).

The analysis of entries on the death certificates revealed great diversity in wording among physicians (Tables 3–6): The least diversity was seen in Case C (29 distinct expressions; Table 4), while the greatest diversity was seen in Case A (80 distinct expressions; Table 2). If we narrowed down the entries to diagnostic semantics, the range of variation decreased from 19 in Case C to 42 in Case A. The combination of expressions ranged from 80 in Case A to 104 in Case B (Tables 3 to 6).

Although the four case history vignettes had different levels of complexity in UCOD determination, the variations in the rates of correct certification format among the four cases were not large, ranging from 71% for Case C to 88% for Case D (Tables 3–6). Nevertheless, the rate of agreement between the referent UCOD and the UCOD provided by the participating physicians showed great variation, ranging from 41% for Case B to 91% for Case C (Tables 3 to 6). If a multiple cause of death scheme was used (i.e., the selected and referent UCOD were considered to agree if the referent UCOD appeared at any place on the cause of death section), the agreement rate increased to 96% for Case A, 74% for Case B, 93% for Case C, and 93% for Case D.

The diagnoses listed in Part II of the cause-of-death section of death certificates varied widely. In Case B, although

Table 6
Diversity in death certification for Case D Vignette among 122 physicians

Classification	No.	%
Distinct expressions used	43	
Distinct diagnostic semantics	26	
Distinct combinations of expressions	101	
Certification format and agreement with referent underlying cause of death (UCOD)		
Correct certification format and same UCOD	71	58.2
Incorrect certification format but same UCOD	22	18.0
Correct certification format but different UCOD	24	19.7
Incorrect certification format and different UCOD	5	4.1
Underlying cause of death		
Acute myocardial infarction (AMI)	90	73.8
Coronary arteriosclerotic heart disease	3	2.5
Arteriosclerosis	2	1.6
Malignant tumor of cecum	16	13.1
Other diagnoses of malignancy	8	6.6
Others	3	2.5
Total	122	100

Referent UCOD: AMI or arteriosclerotic heart disease.

84 physicians listed “CVD,” 31 of these (37%) listed CVD in Part II. In Case C, 119 physicians listed “diabetes,” 42 listed “hypertension,” and 39 listed “coronary heart disease” on the death certificates; however, some of the physicians listed these diagnoses in Part I and some in Part II (11% [13/119] for “diabetes,” 57% [24/42] for “hypertension,” and 59% [23/39] for “coronary heart disease”). In Case D, 89 physicians mentioned malignancy, mostly in Part II (49/89; 55%).

The factor most strongly associated with correct certification format and concordance with referent UCOD was training background (Table 7, Table 8). Having read instructions on death certification and having been taught how to complete death certificates in school or hospital were significantly associated with correct certification format but not with concordance with referent UCOD. Correct certification format and concordance with referent UCOD were not associated with knowledge of cause of death certification.

4. Discussion

The physicians in this study showed great variation in wording and diagnostic semantics in death certification, given the same case history information. The rates of correct certification format did not show great diversity; nevertheless, the rates of agreement with the referent UCOD varied, to a large extent, with the level of complexity in UCOD determination. Physicians showed the greatest diversity in choosing between an acute condition of a chronic disease and the chronic disease per se, i.e., “urinary tract infection” versus “old CVA” in this study. Of the factors analyzed, the training background (medical school versus military) of the physician was the most strongly associated with correct certification format and concordance with referent UCOD. Experience in death certification was associated with only correct certification, not concordance with UCOD; knowledge of death certification was associated with neither.

Table 7
Adjusted odds ratio (OR) and 95% confidence interval (95%CI) of correct certification format in four case vignettes

Characteristic	Case A	Case B	Case C	Case D
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age of physician				
54 and less	1.3 (0.5–3.1)	4.0 (1.4–11.4) ^a	1.5 (0.6–3.8)	2.4 (0.9–6.7)
55–64	0.8 (0.3–2.0)	1.9 (0.7–4.9)	1.0 (0.4–2.5)	1.2 (0.4–3.0)
65 and above	1.0	1.0	1.0	1.0
Training background				
Medical school	2.3 (1.0–4.9) ^a	4.0 (1.7–9.7) ^a	1.3 (0.6–2.8)	2.1 (0.9–4.8)
Non-medical school	1.0	1.0	1.0	1.0
Type of practice				
Hospitals	0.8 (0.3–2.2)	1.3 (0.5–4.0)	1.3 (0.5–3.7)	1.8 (0.5–5.6)
Clinics	1.0	1.0	1.0	1.0
Number of death certificates issued per month				
1 or none	1.7 (0.5–5.5)	0.9 (0.2–3.1)	0.4 (0.1–1.7)	1.7 (0.5–6.0)
2–3	2.5 (0.7–9.3)	4.7 (0.9–25.2)	1.8 (0.4–8.9)	2.1 (0.5–8.3)
4 and above	1.0	1.0	1.0	1.0
Have you ever read the instructions on how to write a death certificate?				
Yes	3.9 (1.7–9.0) ^a	1.9 (0.8–4.4)	2.2 (1.0–5.1) ^a	1.2 (0.5–2.9)
No	1.0	1.0	1.0	1.0
Have you ever been taught how to write a death certificate in school?				
Yes	1.4 (0.7–3.2)	1.3 (0.6–3.2)	2.6 (1.1–6.4) ^a	1.9 (0.7–4.6)
No	1.0	1.0	1.0	1.0
Have you ever been taught how to write a death certificate in a hospital?				
Yes	0.8 (0.4–1.8)	0.6 (0.2–1.3) ^a	1.2 (0.6–2.6)	1.2 (0.5–2.7)
No	1.0	1.0	1.0	1.0
Knowledge of cause-of-death certification ^b				
Good	1.6 (0.6–4.2)	1.4 (0.5–3.8)	0.7 (0.3–1.8)	1.3 (0.5–3.6)
Fair or poor	1.0	1.0	1.0	1.0

^a $p < 0.05$.

^b“Good” indicates that the respondent correctly answered five or more of seven questions regarding cause of death certification; “fair” or “poor” indicates fewer than five questions answered correctly.

The great diversity in wording and diagnostic semantics is not surprising. A study in Sweden revealed that among 1224 death certificates involving rheumatoid arthritis (RA), a total of 1666 types of diagnostic expression could be identified, and 1229 (74%) had been used only once. The 1666 expressions could be coded as 287 different ICD-9 codes. As many as 139 different expressions had been used for RA, and included all varieties of abbreviations and spellings [20].

The primary reason for variation in death certification may be that diversity is an essential part of clinical practice, because each patient is unique. Death certification is not the only medical practice with substantial interpractitioner variability. Variations in history taking, physical examination, interpretations of clinical data, prescriptions of antibiotics, and surgical procedures have long been documented [21,22].

Although the variations in expressions were great in our study, the rates of correct certification format were acceptable (ranging from 71% for Case C to 80% for Case B). Previous studies analyzed the distribution of different types of error in certification format, without taking into account the validity of the UCOD [12–18]. In this study we considered both, and found that some death certificates with incorrect certification format could still yield the correct UCOD. On the other hand, in some death certificates with the correct certification format, the UCOD was different than the referent UCOD (Table 1).

The standard format of the cause-of-death section on death certificates is designed to assist the physician identify the causal sequence of death. Nevertheless, when two or more diseases of different etiology, or one chronic disease with many complications, are present, the physician must decide which is more prominent. Also, there are real problems in untangling the relationships among the different diseases that are present, especially when the attending physician has not had sufficient opportunity to work up the case. Clinically, the situation is not always as clear as the statistician would like it to be.

These difficulties were apparent from our results. In Case B, only two-fifths of the physicians were in agreement with the referent UCOD. A previous study using the same case history showed an even lower agreement rate (15%) [23]. Because many physicians would rather believe that death can be avoided if care is adequate, they might be more likely to indicate ‘urinary tract infection’ or ‘long-term insertion of a urinary catheter’ as the culprit in Case B. By the same token, in Case D, the role of cecum malignancy is very controversial. According to the ACME causal decision table, AMI may be due to hundreds of diseases [19]; it is impossible to rule out the malignancy as the UCOD.

Physicians also showed substantial variation in filling out the diagnosis in Part II (other significant conditions contributing to death but not resulting in the underlying cause

Table 8

Adjusted odds ratio (OR) and 95% confidence interval (95%CI) of concordance with referent underlying cause of death in four case vignettes

Characteristic	Case A	Case B	Case C	Case D
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Age of physician				
54 and less	6.7 (1.4–31.8) ^a	0.4 (0.2–1.1)	3.6 (0.7–18.4)	2.6 (0.8–8.2)
55–64	1.1 (0.4–3.0)	0.6 (0.3–1.5)	1.3 (0.4–5.0)	0.8 (0.3–2.3)
65 and above	1.0	1.0	1.0	1.0
Training background				
Medical school	5.9 (1.9–18.8) ^a	1.1 (0.5–2.3)	6.7 (1.4–31.8) ^a	3.9 (1.5–10.2) ^a
Non-medical school	1.0	1.0	1.0	1.0
Type of practice				
Hospitals	1.4 (0.4–5.4)	0.5 (0.2–1.3)	2.9 (0.4–23.3)	0.7 (0.2–2.0)
Clinics	1.0	1.0	1.0	1.0
Number of death certificates issued per month				
1 or none	1.2 (0.3–4.8)	2.1 (0.6–8.2)	1.9 (0.3–3.2)	0.9 (0.2–5.0)
2–3	2.3 (0.4–12.2)	1.9 (0.8–4.2)	1.6 (0.5–5.2)	0.9 (0.3–2.3)
4 and above	1.0	1.0	1.0	1.0
Have you ever read the instructions on how to write a death certificate?				
Yes	0.4 (0.1–1.3)	1.9 (0.8–4.2)	1.6 (0.5–5.2)	0.9 (0.3–2.3)
No	1.0	1.0	1.0	1.0
Have you ever been taught how to write a death certificate in school?				
Yes	0.6 (0.2–1.7)	0.8 (0.4–1.8)	1.8 (0.5–7.0)	1.1 (0.4–2.7)
No	1.0	1.0	1.0	1.0
Have you ever been taught how to write a death certificate in a hospital?				
Yes	0.7 (0.3–1.8)	1.1 (0.5–2.2)	2.4 (0.7–8.3)	1.1 (0.5–2.6)
No	1.0	1.0	1.0	1.0
Knowledge of cause-of-death certification ^b				
Good	1.3 (0.4–4.2)	1.7 (0.7–4.1)	0.7 (0.2–2.5)	1.1 (0.4–3.0)
Fair or poor	1.0	1.0	1.0	1.0

^a $p < 0.05$.^b“Good” indicates that the respondent correctly answered five or more of seven questions regarding cause of death certification; “fair” or “poor” indicates fewer than five questions answered correctly.

given in Part I) of the cause-of-death section. As Lindahl and colleagues criticized, the definition of contributory conditions may lead to important information being lost in the cause-of-death register and statistics [24]. Many scholars have suggested using multiple-cause-of-death analysis to resolve this problem [25,26]. When we used the multiple-cause-of-death scheme to analyze our results, the rate of agreement with the referent UCOD increased to more than 90% in most cases, except for Case B.

Other reasons for variation in death certification include lack of knowledge of how to complete the death certificate correctly and differences in interpreting information and selecting the UCOD. Several lines of evidence in this study suggest that the main reasons for the above diversities were differences in interpretation of the information and the selection of the UCOD, rather than a lack of knowledge of death certification, as many previous studies assumed [7,8,13,14,23]. First, despite the high rate of correct certification format, the rates of concordance with the referent UCOD were relatively low. Second, experience in death certification (having read instructions, education in school or hospital) was associated with correct certification format only, not with concordance with referent UCOD. Third, knowledge of death certification was associated with neither correct certification format nor concordance with the referent UCOD. Finally, with the exception of Case B, more

than 90% of the respondents listed the referent UCOD on the death certificate—the only differences were the position of the diagnoses.

The implications of this study are twofold. First, from an educational perspective, expert consensus or more rigid guidelines are needed to help resolve the more complex causal sequence determinations, such as selection between severe complications and chronic disease, and between competing prominent comorbidities. Second, from an epidemiologic methodology point of view, we agree with Moriyama's assertion that it is misleading to assume that the accuracy of the diagnosis or the underlying causal sequence can be determined precisely from a review of clinical and pathologic records by practitioners who are not familiar with the actual case [9]. We therefore feel that it is naive to use only one standard ICD code and simple agreement rates to evaluate the quality of death certification.

The limitation of using of case history vignettes is that this method does not embrace the range of real-life clinical conditions, and sustains the Hawthorn bias; that is, the participating physicians may have filled out the death certificates more carefully and in greater detail than usual because they were participating in a study. The variation would likely be greater in real clinical situations, because the same disease can have a variety of expressions, courses, and concomitant conditions.

The convenience sampling method used in this study limits our ability to generalize the results, especially given the more advanced age of the participants and that a relatively high percentage were non-medical school trained. Previous studies showed differences in preferences for some death certification diagnoses among different age groups of physicians [27–29], so the pattern of diversity might be different in samples with higher proportions of young and medical-school-trained physicians.

5. Conclusion

We conclude that primary source of diversity in death certification, especially selection of UCOD, was differences in interpreting the information rather than differences in knowledge of death certification. Thus, the traditional concept of UCOD tabulation and using a single standard ICD code in evaluating the quality of death certification may be an oversimplification of a complex situation. Physicians showed the greatest diversity in choosing between an acute condition of a chronic disease and the chronic disease per se, and in selecting between competing prominent comorbidities. We need more specific guidelines or consensus on these disputable clinical situations to prepare instructions on how to correctly fill out death certificates.

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