

A COGNITIVE APPROACH TO MORTALITY STATISTICS

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Key Words: Death certificates, cognitive methods

In economically developed nations, ascertainment of death is virtually universal. Thus, mortality statistics, and particularly cause-of-death statistics, are the principal source of information about local, state, and national health status, as well as the extent to which health systems are responsive to the needs of populations (Israel, Rosenberg, & Curtin, 1986; Sirken, Rosenberg, Chevarley, & Curtin, 1987). Cause-of-death statistics for a locality are a tabulation of the numbers of individuals that expired due to specified causes (e.g., lung cancer; all cancers) during a specified period of time. These data are compiled from death certificates. The medical certification area of the death certificate is completed by the patient's attending physician, or a coroner or medical examiner, who provides his or her "best medical opinion" about the cause or causes of death. These physician judgments are processed into cause-of-death statistics. Each year, approximately two million people die in the United States; reports on their causes of death are essentially an aggregation of the judgments of the tens of thousands of physicians who certify those deaths.

An axiom of contemporary mortality statistics systems is that for each and every death, there should be a single cause selected for tabulation and presentation in basic reports of mortality statistics. This cause is selected according to rules based on the concept of the underlying cause of death. In the remainder of this introduction, we discuss the task of the certifying physician and differentiate the underlying cause concept from related concepts of cause of death. We then describe some preliminary investigations that we have conducted to explore physicians' understanding of cause of death concepts.

Medical Certification of Death

Although each vital registration area in the United States (50 states, New York City, District of Columbia, Puerto Rico, Virgin Islands, and Guam) has its own death certificate, the medical certification sections of the various death certificates have much in common. The certification section consists of two parts (see Figure 1). Part I contains either three or four lines, and the physician is instructed to "enter the diseases, injuries, or complications that caused the death." On the top line of the section, the physician is to enter the immediate cause, which is defined on the U.S. Standard Certificate of Death as the "final disease or condition resulting in death." On the remaining lines of Part I, the physician is to "sequentially list conditions, if any, leading to the immediate cause," entering the underlying cause on the *last used line*. The internationally accepted technical definition of the underlying cause is "the disease or injury which initiated the train of morbid events

leading directly to death, or the circumstances of the accident or violence which produced the fatal injury" (World Health Organization, 1977, p. 700). In Part II of the certificate, the certifier is to list "other significant conditions contributing to death but not resulting in the underlying cause given in Part I." All of the information entered by the certifier on the death certificate is potentially valuable. However, by far the most important use of the death certificate for public health purposes is to extract the underlying cause of death from the information provided by the certifier. Although selection and modification rules applied by nosologists coding the death certificates may override what physicians report on the last used line of Part I (World Health Organization, 1977, pp. 701-712), valid data on the underlying cause of death is dependent on the ability of certifiers to accurately report the underlying cause of death.

The current format of the cause of death section of the death certificate is based on a particular set of assumptions about how a physician does (or should) make judgments about the cause of death so as to provide information that will result in selection of the "most appropriate" disease as the underlying cause of death. Specifically, the certificate is designed to help the physician reason from the immediate cause to the underlying cause. It instructs the physician to specify in Part II other significant contributing conditions, which unfavorably influenced the course of the morbid process and thus contributed to the fatal outcome, but which were not related to the underlying cause given in Part I. The intent is to elicit from the physician statements about other conditions present in the patient and to induce the physician to assert that these were not the underlying cause of death.

We note that although it has been assumed that physicians will most effectively identify the underlying cause of death by engaging in such a reasoning process and by explicitly excluding other alternatives, there currently is no empirical evidence to support these assumptions.

Concepts of Cause of Death

As mentioned above, the immediate cause is the final disease or condition that results in death, and the underlying cause is the disease or injury that initiates the train of events that culminates in death. The certifier is not required to list more than one condition in Part I, but if more than one entry is made in Part I, the listed conditions, on a correctly completed certificate, will constitute a pathophysiologically valid sequence originating in the lowest listed condition and culminating in the highest listed (see Figure 1). For purposes of the certificate, the concepts of immediate and underlying causes are defined by the location in which the entry is made as well as by the

meanings discussed here. In addition, if a certifier enters only one condition in Part I, it is selected as the underlying cause.

Proper completion of the cause-of-death section of a death certificate requires an understanding of two additional concepts--mode of dying and other significant conditions. Mode of dying is a term that is defined almost universally by example; common examples are cardiac arrest, respiratory arrest, shock, and heart failure. An apt, abstract definition is description of the mechanism of death. Instructions on the death certificate urge certifiers not to specify modes of dying as the only cause of death because such terms are descriptive rather than explanatory. Modes of dying fail to discriminate in any useful way among deaths and are uninformative with regard to the disease process that should be confronted by public health authorities. In Part II of the cause of death section, the certifier may list other conditions that he or she believes contributed significantly to the death but that are unrelated to the sequence specified in Part I. No condition listed in Part II is to be a condition that gave rise to the underlying cause listed in Part I.

Numerous methodological studies have demonstrated that the underlying cause of death is often reported inaccurately on death certificates (e.g., Percy, Stanek and Gloeckler, 1981, Corwin et al. 1982). Although these errors are unlikely to be due to a single factor, a lack of understanding of the cause of death concepts on the death certificate by the certifying physician would greatly increase the likelihood of incorrect certification.

One objective of this paper is to communicate some preliminary findings about physicians' formal understanding of the concepts of cause of death (as revealed by their definitions). We initially look at respondents' understanding of the terms immediate cause of death and mode of dying, and their ability to discriminate between the two. Both occur close to or at the time of death, and it is widely believed that physicians quite frequently enter the mode of dying instead of the immediate cause of death on the top line of the death certificate (Kircher and Anderson, 1987). A similar examination was conducted of the terms underlying cause of death and other significant conditions contributing to death but not resulting in the underlying cause. To more vividly portray physicians' understandings of these concepts, a number of respondents' verbatim responses are presented.

The other objective of the paper is to explore the relationship of respondents' practical understanding of cause of death (as revealed by their spontaneous discussions about vignettes) to the formal concepts pertaining to cause of death (as revealed by their responses to specific questions about the immediate and underlying causes of death for a vignette).

Method

As part of the development process for a national survey of physicians concerning their knowledge of death certification concepts and their attitudes and practices regarding death certification, pilot interviews were

conducted with a convenience sample of twenty physicians in Maryland, Virginia, and the District of Columbia. The sixteen interviews for which a good quality recording was obtained are reported in this paper. Physicians were identified from lists of individuals who had certified deaths that were provided by the vital statistics offices of these registration areas. From these lists, individual physicians were contacted until sufficient interviews had been arranged to meet a target of approximately twenty interviews.

Respondent Characteristics

The mean age of the 16 respondents reported in this paper was 39 (range 28-65). Three were residents and two were fellows; of the remaining eleven, seven described their practices as primarily office-based, and four as primarily hospital-based. Internal medicine (one with geriatrics) was indicated by 6 respondents as the specialty in which they had spent the major portion of their working time in the past 12 months; family practice was indicated by 2; and the following were indicated by one respondent each: otolaryngology, hematology, hematology and oncology, oncology, general medicine and urology (two respondents were not asked). Twelve respondents reported being certified in at least one specialty board. Excluding one respondent who reported certifying about 250 deaths, mean number of deaths certified in the past 12 months was reported as 16.2 (range from 0 to 40). However, most respondents indicated considerable uncertainty about the actual numbers.

Interview Procedure

One of the researchers conducted a face-to-face interview with each physician, administering a questionnaire that covered a wide range of topics relating to the respondents' knowledge, attitudes and practice regarding death certification. Interviews were audio-taped; most were conducted in the physician's office and lasted somewhat less than 50 minutes. The questionnaire items described in this paper were administered near the beginning of the interview, immediately after questions about the respondent's training and current medical practice. Responses to these items were subsequently transcribed verbatim and analyzed. A description of these items follows:

Vignettes. Most respondents were asked to read two vignettes, each of which described the case of a patient who had been admitted to a hospital and subsequently died. The vignettes were modified versions of two vignettes used in the *Physicians' Handbook on Medical Certification of Death* (NCHS, 1987). Each described a type of death that is quite common. One (case history No. 3 in the Handbook) described an eighty-five year old male who expired after experiencing chest pains. The Handbook gave the immediate cause as acute myocardial infarction, and the underlying cause as arteriosclerotic heart disease. The other (case history No. 7) described a fifty-five year old male who smoked, and expired shortly after being admitted to an emergency room complaining of shortness of breath and coughing. The Handbook gave the immediate cause of

death as severe obstructive airways disease, and the underlying cause as cigarette smoking. Because an important focus of the paper is the relative salience of the immediate and underlying cause of death, the order of presenting the information in the vignettes was counterbalanced (a forward temporal order vs. a backward temporal order). The vignettes themselves were also counterbalanced over respondents.

After the respondent read the first-presented vignette, he/she was asked "to talk to [the interviewer] about the cause or causes of death". After finishing his/her account, the respondent was asked to read the second-selected vignette, and then to talk about the cause or causes of this death.

Definitions of cause-of-death concepts. Each respondent was asked to define four terms that appear on the death certificate--immediate cause of death, underlying cause of death, other significant conditions contributing to death but not resulting in the underlying cause (hereafter abbreviated to other significant conditions), and mode of dying. All respondents received these questions in this order. These questions followed the vignettes in those interviews that included vignettes. After being asked the meaning of immediate cause of death, the respondent was asked to state the immediate cause of death of the patient in the second-read vignette; similarly, after being asked what underlying cause means, the respondent was asked to state the underlying cause of death of the patient in the second vignette.

Results

Here we present the results of the physicians' formal understanding of cause of death concepts. The answers of the sixteen respondents who gave definitions of the terms can be categorized as follows.

Mode of Dying and Immediate Cause of Death

All of the physicians demonstrated an understanding of one of the two terms, immediate cause of death and mode of dying. However, only 4 of the 16 respondents demonstrated an understanding of the definitions of the two terms and distinctions between them. For example, respondent FS1 stated that, "The immediate cause is the actual diagnosis that describes why somebody expired, and it's not the mechanism by which they expired... I guess the term mode of dying would be the actual mechanical--or physical--event that happened... something like respiratory arrest or cardiogenic shock."

Six respondents demonstrated an understanding of the distinction between immediate cause and mode of dying, but did not adequately define one or both terms. For example, respondent DM4 stated that the immediate cause was, "What actually caused the death.... the event that caused the patient's death; disregards any of the events that may have led up to the death...;" and stated regarding the mode of dying, "I have no idea what this means. Could mean many things; what the actual cause was, whether the patient died by accident or by natural causes or by trauma."

Six respondents could not differentiate between the

terms, but appeared to have some understanding of the meaning of immediate cause. For example, respondent FS4 defined the immediate cause as, "The precipitating factor that took the patient's life at that particular time;" and for the mode of dying stated that, "I'm not sure what they mean by that--mode of dying--I have no idea."

Underlying Cause and Other Significant Conditions

Only 3 of 16 physicians demonstrated an understanding of the definitions of and distinctions between underlying cause and other significant conditions. For example, respondent DM3 defined underlying cause as, "The disease process underlying the terminal event, for instance, in this man it is the arteriosclerotic heart disease... Underlying cause is a cause that does not require another to explain it;" and defined other significant conditions as, "Like a disease which may aggravate or worsen the underlying cause, may make the patient more susceptible to underlying conditions, but which are not pathophysiologically a cause of or result of the underlying cause...."

Five physicians demonstrated an understanding of the distinction between underlying cause and other significant conditions, but did not adequately define one or both terms. For example, respondent JW1 stated that the underlying cause was, "The cause of the cause of death. Longitudinal diagnosis associated with the acute event...;" and defined other significant conditions as, "...the diseases associated with patient's medical history that are contributory; they can alter the course of the underlying cause."

Four physicians did not differentiate between underlying cause and other significant conditions, but appeared to have some understanding of the meaning of one of the terms. For example, respondent FS3 stated that the underlying cause was, "The condition or disease that led to or predisposed the patient to other comorbid conditions, including the one that may have caused their death;" and defined other significant conditions as, "Other comorbid conditions that were debilitating."

Two physicians did not demonstrate an understanding of the distinction between either terms. For example, respondent HR1 when asked to define the underlying cause stated that, "Underlying medical conditions are those that may have contributed to the patient's overall state of health or to have led up to contributing causes of death, but not necessarily to the principle illness or diagnosis." When asked to define other significant conditions, the respondent stated, "Nebulous. It depends on a multitude of diagnoses that the patient has. Could have many things, including chest pain and then expires..."

Finally, 3 respondents gave definitions of underlying cause of death that were clearly incorrect, and four gave incorrect definitions of other significant conditions.

Application of Cause of Death Concepts

We compared respondents' verbatim responses to the invitation to talk about the cause or causes of death in the second vignette that they read with their answers to the subsequent questions asking them to specify the immediate and underlying cause of death in that second vignette.

When talking about the cause or causes of death for this vignette, ten respondents indicated a single condition as the cause of death (i.e., they described this cause in such a way as to make clear that they thought this was the primary condition which resulted in the patient's death). For eight of these respondents this was the condition they subsequently categorized as the immediate cause of death, for one it was the condition he subsequently categorized as the underlying cause of death, and for one respondent it was neither.

Two respondents placed equal emphasis on two conditions when talking about the cause or causes of death for the second-presented vignette. They subsequently categorized these two conditions as the immediate and underlying causes of death. Two respondents' descriptions of the vignette were too tentative for a determination of what they regarded as the cause or causes of death.

In addition, 13 of the above respondents mentioned a condition as being "secondary to" another cause of death when talking about the cause or causes of death for the second-presented vignette. For five of these respondents, this was the condition that they subsequently categorized as the immediate cause of death. No respondents reported a "secondary to" condition that they subsequently categorized as the underlying cause of death. For example, respondent DM1 stated that death was due to, "Acute respiratory failure secondary to emphysema;" and in response to specific questions stated that the immediate cause of death was acute respiratory failure and the underlying cause of death was emphysema. Others used the term "primary" cause to refer to causes that they subsequently described as the immediate cause.

Discussion

Numerous studies using a variety of methodologies and examining a wide variety of types of deaths have demonstrated a high level of both variability and error in cause of death reporting on death certificates (e.g., Percy, Stanek and Gloeckler, 1981; Corwin et al., 1982). Explanations that have been advanced for this include a lack of knowledge of what caused the patient's death (due in part to the infrequency with which autopsies are conducted) (Kircher, 1990), the inappropriateness of requiring a single causal sequence as the primary description of the death when the deceased was an elderly individual with multiple chronic health conditions (Moriyama, 1989), the certifier's specialty training (Sorlie, 1987), the certifier's lack of motivation to accurately complete a death certificate, and his or her lack of knowledge regarding how to complete it. This last explanation has usually been advanced based on anecdotal evidence that most physicians have received little or no training on death certification.

No published supporting empirical evidence has been advanced, and no assessment has been made of what physicians know and do not know about death certification. The research described in this paper investigated one aspect of this last claim, namely whether physicians lack knowledge regarding the meaning of important concepts on the death certificate. In addition, we explored the

relationship between how physicians spontaneously talk about the cause or causes of death of a patient, and the information about causes of death that must be entered on the death certificate. A mis-match between these would make more difficult the task of completing the cause of death section of the death certificate, and increase the likelihood that errors would occur.

Two important caveats need to be made about the results. The first is that the data reported in this paper were obtained from interviews with a small opportunity sample of physicians. Thus, although we know of no reason why respondents would tend to perform more poorly on this task than would a random sample of certifiers—and indeed, can think of a number of reasons why the reverse may be true—we can not know the extent to which these preliminary findings would generalize to all physicians who certify deaths. This could be ascertained only by means of larger-scale replications of these findings using a probability sample of physicians.

The second caveat is that, as with all analyses of responses to open-ended questions, there is an element of subjectivity when deciding how to categorize an individual response. We feel confident, however, that whereas there is room for disagreement about the exact numbers assigned to any particular category, the general findings are robust.

In the remainder of this section we summarize what we believe are the most important findings of this study, and briefly discuss their implications.

Mode of Dying and Immediate Cause of Death

Perhaps the most striking finding is that, although the instructions on the cause of death section of the death certificate specifically instruct the certifier not to enter the mode of dying as the cause of death, and provide examples of modes of dying (see Figure 1), only six respondents were able to correctly define the term. This included three respondents who made statements suggesting that they did not know the term, but had been able to infer its meaning. Five respondents incorrectly reported that the term meant manner of death, that is, accident, homicide, suicide or natural death. The remaining five respondents indicated that they did not know the meaning of the term.

It is noteworthy, however, that comments made by three respondents who did not understand the term indicated a belief that they were not allowed to enter a mode of dying on the death certificate. This may reflect efforts by some state health departments and hospital records departments to correct physicians who make such entries, at least as the sole condition in Part I of the cause of death section.

The term immediate cause of death was better understood than mode of dying. All sixteen respondents offered definitions of immediate cause of death, and none were clearly wrong. Nevertheless, the vagueness and ambiguity of the majority of respondents' definitions suggest that most respondents had an incomplete understanding of the meaning of the term. Of course, even individuals as verbally skilled as physicians may have difficulty expressing their knowledge of a concept in words; thus many respondents may have a better understanding of

the immediate cause of death than their definitions would suggest.

Given the anecdotal evidence that physicians often enter the mode of dying rather than the immediate cause on the top line of Part I of the cause of death section of the death certificate, we examined respondents' ability to discriminate between the terms. Six of the 16 respondents failed to demonstrate any ability to discriminate between the terms. Should these results hold for all physicians who certify deaths, numerous physicians may indeed erroneously be entering a mode of dying instead of the immediate cause on the death certificate.

Underlying Cause and Other Significant Conditions

As was discussed earlier, the primary purpose of the death certificate is to obtain the decedent's underlying cause of death. Thus it is troubling that three respondents gave an incorrect definition of the underlying cause of death, and only three respondents gave definitions that were fully adequate. It should be noted, however, that other respondents may well have been able to give correct definitions, including many of those who gave examples rather than definitions in the interview.

Examining respondents' definitions of underlying cause and other significant conditions revealed that only two respondents failed to demonstrate any ability to distinguish between these terms. This suggests that respondents were somewhat better at discriminating between underlying cause and other significant conditions than between immediate cause of death and mode of dying.

In summary, the physicians interviewed appeared to differ greatly in their understanding of the cause of death concepts used on the death certificate. Many demonstrated significant error or uncertainty in their understanding of the terms immediate and underlying cause of death, other significant conditions, and mode of dying. Should these results pertain to a representative sample of certifiers, considerable inconsistency and error is likely to be introduced into national tabulations of cause of death statistics.

In addition, although no systematic attempt to measure this was made, there appeared to be a significant amount of within-subject variability in defining the terms mode of dying, immediate cause of death, underlying cause and other significant conditions. An appreciable number of respondents contradicted themselves while defining one or more of the terms. This adds to the evidence that many respondents lacked well-articulated definitions of these terms. In order to give a definition, such respondents would need to employ inferential reasoning and other reasoning heuristics. Such "constructing" of the definition appeared to be most common for the term mode of dying.

Application of Cause of Death Concepts

Each respondent who read the case vignettes had two opportunities to make statements about the causes of death of the patient in the second-read vignette: The first opportunity was when he or she was talking about the cause or causes of death; the second was when he or she was

asked to specify immediate and underlying causes after defining these concepts. When respondents first read the vignettes, they were aware that the interview in which they were participating was primarily concerned with death certification, but the specific terms that are used on the death certificate had not yet been mentioned by the interviewer. We therefore view the comments made by physicians during the initial reading of the vignettes as a window into their spontaneous way of thinking about cause of death. A high level of spontaneous thinking about the underlying cause of death would suggest that this is a salient concept for respondents, and thus that a minimal burden is placed on physicians when they are required to enter the underlying cause on the death certificate. In addition, respondents who refer to what they later specified as the underlying cause of death as the cause of death when spontaneously talking about the vignette are demonstrating that they accord the same high importance to the concept as do users of cause of death data.

The results, described earlier, are quite clear. The majority of respondents referred not to the cause that they later specified as the underlying cause of death when they talked about the cause or causes of death, but to what they later specified as the *immediate* cause. However, although apparently of lower salience for most respondents, the later-specified underlying cause of death also was reported by most respondents when talking in their own words about the cause or causes of death.

Another important finding in the spontaneous comments by physicians is that many use different terminology when referring to causes of death than are used on the death certificate. Physicians referred not to immediate and underlying causes of death, but to primary and secondary causes of death (e.g., acute respiratory failure secondary to emphysema). This could partially explain the difficulty physicians have in defining the terms immediate cause of death and underlying cause of death.

Nevertheless, certain aspects of the experimental methodology makes it somewhat uncertain as to whether the findings would apply to actual death certifications. Only two vignettes were used; other case histories might produce different results. In addition, vignettes may not capture important aspects of physicians' knowledge about patients in real-life. Clearly, a replication using actual cases would be a valuable check on the generalizability of the findings.

Future Directions

It is anticipated that subsequent stages of this research program will use larger numbers of respondents, probability sampling procedures, and refinements in the questioning procedures to look further at physicians' understandings of the concepts used in death certificates, and the relationship between the way that physicians spontaneously talk about the cause or causes of a death and the information on cause of death that is required to be entered on the death certificate. This research has a rich potential for improving the quality of cause of death statistics. For example, identifying the most serious deficiencies in physicians' knowledge regarding death certification should allow us to

develop instructions on the death certificate, supporting materials, and educational courses that can remedy the deficit. In addition, these findings could inform future redesigns of the death certificate to narrow the gap between how physicians spontaneously think about the cause of death and the information on cause of death required on the death certificate. Finally, a better understanding of the sources of errors in cause of death reporting will help epidemiologists and public health officials decide how much trust to place in the cause of death data that they use, and to better estimate the nature and severity of error in these data.

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Author Notes

The research reported in this paper was supported by DHHS Contract 292-91-7031 between the National Center for Health Statistics, Centers for Disease Control, and the Research Foundation of the State University of New York. We appreciate the valuable assistance of Harry Rosenberg, George Gay, Richard Roberts, and Mark Kloberdanz in conceptualizing this project, collecting data, and constructive comments on earlier versions of this manuscript. We are also deeply indebted to the physicians who gave freely of their valuable time. Finally, we are indebted to staff of the vital statistics offices, Daniel Hughes (Maryland), Russell Booker and Kay Brooks (Virginia), and Carl Wilson (District of Columbia) who provided the names of physicians who certified deaths.

Figure 1. Medical Certification Section of the U.S. Standard Certificate of Death

SEE INSTRUCTIONS ON OTHER SIDE

CAUSE OF DEATH

27. PART I. Enter the diseases, injuries, or complications that caused the death. Do not enter the mode of dying, such as cardiac or respiratory arrest, shock, or heart failure. List only one cause on each line.

IMMEDIATE CAUSE (final disease or condition resulting in death)	a. Rupture of myocardium DUE TO IOR AS A CONSEQUENCE OF:	Approximate interval Between Onset and Death Mins.
Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST	b. Acute myocardial infarction DUE TO IOR AS A CONSEQUENCE OF:	6 days
	c. Chronic ischemic heart disease DUE TO IOR AS A CONSEQUENCE OF:	5 years
	d.	

PART II. Other significant conditions contributing to death but not resulting in the underlying cause given in Part I.

Diabetes, Chronic obstructive pulmonary disease, smoking

28a. WAS AN AUTOPSY PERFORMED? (Yes or no) Yes

28b. WERE AUTOPSY FINDINGS AVAILABLE PRIOR TO COMPLETION OF CAUSE OF DEATH? (Yes or no) Yes

29. MANNER OF DEATH

Natural Pending Investigation

Accident Could not be Determined

Suicide Homicide

30a. DATE OF INJURY (Month, Day, Year)

30b. TIME OF INJURY M

30c. INJURY AT WORK? (Yes or No)

30d. DESCRIBE HOW INJURY OCCURRED

30e. PLACE OF INJURY—At home, farm, street, factory, office, building, etc. (Specify)

30f. LOCATION (Street and Number or Rural Route Number, City or Town, State)