

## ON THE RELATIONSHIP OF MORTALITY STATISTICS AND DEATH CERTIFICATE FORMAT

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Mortality statistics are compiled from physicians' entries on death certificates. Following the death of an individual, a certifier completes a death certificate, offering his or her best medical opinion about the cause of death. The precise format of the cause-of-death section of the death certificate has evolved, over the last century, to accommodate the inclinations of physicians and to collect the best possible information. Figure 1 shows the cause-of-death section from the current version (1989 revision) of the U. S. Standard Certificate of Death.

The United States comprises many registration districts, each of which has its own death certificate. (Each state and the District of Columbia is a separate vital registration area, as is New York City.) Despite the variability among certificates, the cause-of-death section of each local certificate is based on that of the U.S. Standard Certificate of Death, which itself is based on the form recommended by the World Health Organization.

As exemplified in Figure 1, all cause-of-death sections consist of two parts. The purpose of Part I is to collect information from the certifier about the principal causes of death; the goal of Part II is to collect information about conditions that contributed to death but that were considered by the certifier to be unrelated to the set of morbid events described in Part I.

Part I of the cause-of-death section consists of a series of lines connected by the words "DUE TO (OR AS A CONSEQUENCE OF)". The design of Part I of the cause-of-death section is intended to encourage certifiers to engage in a backwards chain of causal reasoning; the objective of this reasoning process is to specify the event that initiated the sequence of morbid events that culminated in death. (The format presumes a linear sequence of morbid events that can be traced to a single initiating cause.) Ideally, the certifier, after entering any condition in Part I, would ask himself or herself whether this condition could be attributed to some other condition, and if so, would enter that condition on the next line. Using the certificate's terminology, the certifier is to enter the *immediate cause* on the top line of Part I, and is then to enter a sequence of causes, working down to the *underlying cause*, defined on the certificate as "the disease or injury that initiated events resulting in death". In many cases, this last-listed condition would be selected for tabulation as the cause of death. Both for uniformity of procedure over certifiers and over cases, and to satisfy the underlying cause concept, all certifiers should always

engage in such a chain of reasoning to arrive at the initiating cause.

Concern has been expressed from time to time over the past half century about whether certifiers do in fact apply a uniform methodology to certification. An issue that has attracted particular attention is whether certifiers actually reason back to the initiating cause. Suspicion has been expressed, for example, that certifiers terminate prematurely the backward chain of reasoning. Among the possible consequences of such a practice could be, for example, underestimation of the extent to which death is due to chronic, or long-standing conditions, and overestimation of the rate at which death is due to more acute conditions.

The research described in this article represents an empirical approach to this causal reasoning problem. The issue addressed in the study described here is whether experimental versions of the cause-of-death section promote deeper causal reasoning than the standard cause of death-section shown in Figure 1.

Before detailing the empirical investigation, we describe the process by which the underlying cause of death is selected for tabulation. A fundamental axiom of most mortality statistics systems is that the number of causes tabulated should equal the number of people who died. Regardless of the number of conditions recorded on the death certificate, just one condition is selected for tabulation. In general, the preferred cause for tabulation is the disease or injury that initiated the sequence of morbid events that culminated in death. As indicated above, ideally the condition entered by the certifier on the last-used line of Part I is precisely this cause. Under some circumstances, however, the initiating cause is not selected for tabulation. The World Health Organization has developed a set of rules according to which a condition is selected for tabulation from among the conditions entered on the death certificate: The *General Rule* is that if all conditions on the upper lines of Part I are valid consequences of a condition entered on the last-used line of Part I, the latter condition is selected. Under some circumstances the *General Rule* is not applicable. For example, it may be that not all conditions entered by the certifier in Part I are valid consequences of the condition on the last-used line, or a condition listed in Part II of the cause-of-death section may be a compelling antecedent of the last-entered condition in Part I. In such cases, a specialized rule guides selection of an underlying cause of death for the decedent. Other situations that require a special rule to select the underlying cause are those in

| 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.                 |  | Approximate Interval Between Onset and Death |
|---|--|--|
| IMMEDIATE CAUSE (Final disease or condition resulting in death) →<br><br>Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST | a. _____<br>DUE TO (OR AS A CONSEQUENCE OF): |  |
|   | b. _____<br>DUE TO (OR AS A CONSEQUENCE OF): |  |
|   | c. _____<br>DUE TO (OR AS A CONSEQUENCE OF): |  |
|   | d. _____<br>DUE TO (OR AS A CONSEQUENCE OF): |  |
| PART II. Other significant conditions contributing to death but not resulting in the underlying cause given in Part I.  |  |  |
| _____   |  |  |

Figure 1. The cause-of-death section from the U. S. Standard Certificate of Death, 1989 revision.

which it is not the initiating cause, but rather some sequel of that cause, that is preferred for tabulation. For example, in most cases in which a myocardial infarction is reported as a cause of death, it is tabulated as the underlying cause of death, regardless of whether the myocardial infarction is asserted to be due to some other condition (e.g., a chronic heart condition).

Because the term "underlying" is potentially ambiguous, in the remainder of this article we distinguish between the *underlying cause* and the *initiating cause*. The term *initiating cause* is used to refer to the disease (or external event) that initiated the sequence of morbid events that resulted in death. The term *underlying cause* is reserved for the medical entity that is selected for tabulation from a properly completed death certificate.

Generally, the initiating cause is the cause of paramount importance for statistical purposes. However, the implication of the preceding discussion is that the optimal certification is genuinely a complete sequence of medical entities in which the last entry is the initiating cause. Although in many cases, the correct underlying cause would be abstracted from the certificate if the sole entry on the certificate were the initiating cause, this would not always be true. For example, the abstracted underlying cause for an individual who experienced a myocardial infarction due to chronic coronary artery disease would not be correct if the only entry on the certificate were *chronic coronary artery disease*; the international rules for underlying cause selection specify that in the case of a myocardial infarction due to coronary artery disease, the selected underlying cause would be *myocardial infarction*.

As indicated earlier, the objective of this study was to assess whether certain modifications of the cause-of-death

section would improve reporting of the initiating cause. The underlying rationale is that the reporting by certifiers of longer sequences of conditions leading to death enhances the likelihood that the initiating cause will be reported. Thus, certifications of described deaths using three experimental cause-of-death sections were compared to certification using the standard cause-of-death section. Although the methodology will be described in greater detail later, the general procedure involved asking physicians attending continuing medical education meetings to read a case vignette and to complete a cause-of-death section for the described case.

#### Experimental Cause-of-Death Sections

A curious aspect of the current format of the death certificate is that despite the emphasis placed on the initiating cause of death by the vital statistics community, no location on the certificate is dedicated to that cause. As described earlier, and as shown in Figure 1, the certifier is to record the initiating cause on the last-used line of Part I, and so it goes wherever it ends up. Two of the experimental versions of the cause-of-death section used in this study emphasized to the certifier the importance of recording the initiating cause.

In the *shaded-line* version, shown in Figure 2, a box was drawn around line d of Part I, and the box was shaded grey. An additional instruction, "Enter UNDERLYING CAUSE in this box", was added adjacent to the words "DUE TO (OR AS A CONSEQUENCE OF):".

The *underlying-cause-box* version, shown in Figure 3, included a standard Part I. However, between Parts I and II, a box was added in which the certifier was to enter the initiating cause. An instruction in the box stated: "In this box, enter the UNDERLYING CAUSE (Disease or injury

|   |  |  |
|---|--|--|
| 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. |  | Approximate Interval Between Onset and Death |
| IMMEDIATE CAUSE (Final disease or condition resulting in death) →   | a. _____<br>DUE TO (OR AS A CONSEQUENCE OF):   |  |
| Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) in the box provided.  | b. _____<br>DUE TO (OR AS A CONSEQUENCE OF):   |  |
|   | c. <span style="background-color: #cccccc;">_____</span><br>DUE TO (OR AS A CONSEQUENCE OF): Enter UNDERLYING CAUSE in this box. |  |
|   | d. _____   |  |
| PART II. Other significant conditions contributing to death but not resulting in the underlying cause given in Part I.  |  |  |
| _____   |  |  |
| _____   |  |  |

Figure 2. The shaded-line version of the cause-of-death section.

that initiated events resulting in death). Please enter the UNDERLYING CAUSE here even if you have already written it elsewhere on this certificate".

Each of these experimental versions thus provides a specific place for the initiating cause and a specific reiteration that it is to be written on the certificate.

The rationale for the third experimental cause-of-death section, the *mode-checkbox* version shown in Figure 4, was somewhat different. Physicians are often inclined to enter the mode of dying on the death certificate even though the instructions in Part I state that the mode of dying is not to be entered (Smith, Mingay, Jobe, Weed, & Clark, 1992). The mode of dying is the mechanism of death; representative modes of dying are cardiac arrest and respiratory arrest. From a public health perspective, the mode of dying is not informative, even if a certifier regards it as the event that made the difference between life and death for a particular individual. The mode-checkbox version of the cause-of-death section asked the certifier to indicate the mode of dying by checking one of an offered set of alternatives prior to entering the causes of death in Part I. This format was intended to have two effects: First, it was intended to indicate to certifiers that the mode of dying is not a cause of death; second, to the extent that entering a mode of dying in Part I displaces other medical conditions that could have been entered, the mode-checkbox version was expected to elicit longer sequences of informative medical conditions and to increase reports of the initiating cause.

## Method

### Materials

Four vignettes were prepared. Each described the

death of a fictitious patient. Three of the vignettes were selected from the National Center for Health Statistics's *Physicians' Handbook on Medical Certification of Death* (National Center for Health Statistics, 1987); the fourth was prepared for this project. In this article, we refer to the vignettes by their initiating conditions: *non-insulin-dependent diabetes mellitus*; *chronic ischemic heart disease*; *smoking*; and *carcinoma of lung*.<sup>1</sup>

Four cause-of-death sections were used. These were described in the introduction and shown in Figures 1, 2, 3, and 4.

### Design and Procedure

After obtaining approval from course directors to seek

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For several of these vignettes, the underlying cause that would be abstracted from a complete certification of the case differs from the initiating cause. For example, in the case to which we refer as the *chronic ischemic heart disease* case, the patient, afflicted with chronic heart disease for eight years, experienced a myocardial infarction and a pulmonary embolism before she died. For this case, the initiating cause is *chronic ischemic heart disease*, but application of the WHO selection and modification rules to a complete certification would yield an underlying cause of *myocardial infarction*. In the *smoking* case, years of smoking apparently caused chronic obstructive pulmonary disease, chronic bronchitis, and acute exacerbation of chronic obstructive pulmonary disease. The initiating cause of death is *smoking*; the underlying cause that would be selected by application of the rules to a complete certification is *chronic bronchitis*.

|  |   |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
|--|---|----|----------------------------------|--|----|----------------------------------|--|----|----------------------------------|--|----|--|--|
| <p>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.</p>   | <p>Approximate Interval Between Onset and Death</p>   |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| <p>IMMEDIATE CAUSE (Final disease or condition resulting in death) →</p> <p>Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST</p>   | <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 5%; text-align: center;">a.</td> <td style="border-bottom: 1px solid black;">DUE TO (OR AS A CONSEQUENCE OF):</td> <td style="border-left: 1px dashed black; width: 20%;"></td> </tr> <tr> <td style="text-align: center;">b.</td> <td style="border-bottom: 1px solid black;">DUE TO (OR AS A CONSEQUENCE OF):</td> <td style="border-left: 1px dashed black;"></td> </tr> <tr> <td style="text-align: center;">c.</td> <td style="border-bottom: 1px solid black;">DUE TO (OR AS A CONSEQUENCE OF):</td> <td style="border-left: 1px dashed black;"></td> </tr> <tr> <td style="text-align: center;">d.</td> <td style="border-bottom: 1px solid black;"></td> <td style="border-left: 1px dashed black;"></td> </tr> </table> | a. | DUE TO (OR AS A CONSEQUENCE OF): |  | b. | DUE TO (OR AS A CONSEQUENCE OF): |  | c. | DUE TO (OR AS A CONSEQUENCE OF): |  | d. |  |  |
| a.   | DUE TO (OR AS A CONSEQUENCE OF):  |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| b.   | DUE TO (OR AS A CONSEQUENCE OF):  |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| c.   | DUE TO (OR AS A CONSEQUENCE OF):  |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| d.   |   |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| <div style="border: 1px solid black; padding: 5px; margin: 5px auto; width: 80%;"> <p>In this box, enter the UNDERLYING CAUSE (Disease or injury that initiated events resulting in death). Please enter the UNDERLYING CAUSE here even if you have already written it elsewhere on this certificate.</p> </div> |   |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |
| <p>PART II. <u>Other significant conditions</u> contributing to death but not resulting in the underlying cause given in Part I.</p> <hr style="border: 0; border-top: 1px solid black; margin: 5px 0;"/>  |   |    |                                  |  |    |                                  |  |    |                                  |  |    |  |  |

Figure 3. The underlying-cause-box version of the cause-of-death section.

participation from physicians attending three continuing medical education meetings, materials were distributed to physicians attending the meetings. The packet distributed to each physician included a case vignette, a cause-of-death section, and a questionnaire concerning demographic characteristics. These materials were distributed in an envelope on which instructions were printed; the instructions implored each potential participant to read the instructions before opening the envelope, to wait to open the envelope until he or she had about five minutes during which he or she could concentrate on this activity, and, at that time, to open the envelope, read the case vignette, and answer the questions about the case. (In this study, the questions consisted of the certification of cause of death.) Participants were asked to return their completed materials to the investigator, who was available throughout the day to collect responses. Participants were asked to refrain from discussing the study with colleagues.

The four certificate conditions were crossed with the four vignettes, and packets were collated so that one of each of the 16 different combinations of vignette with cause-of-death section was distributed in every 16 packets. The different cause-of-death sections represent experimental conditions; the different cases represent, essentially, four different replications of the experiment.

### Participants

Responses were collected (and data are reported) from 613 physicians. These included 143 physicians attending a board review course in family medicine and 470 physicians attending two different sections of a general

medicine update course. These physicians represented approximately 50% of the attendees at these meetings.

### Results and Discussion

The data of primary interest are the frequencies with which various conditions were stated to be the underlying cause of death. Prerequisite to an examination and interpretation of those data, however, is an analysis of the frequency with which physicians responded to the various case replications and certificate formats.

#### Response Distribution Over Conditions and Replications

A physician attending a continuing medical education meeting or board review course might decline to participate in a study such as this for any of a variety of reasons. We do not know what characteristics distinguish participants from physicians who decline to participate. However, to make statements about the impact of certificate format on responses, what is important is not the response rate, but that there not be differential response rates across formats for any replication.

The first four data columns of Table 1 show how many responses were collected for each certificate version for each case; the last column on each line of the table gives the  $\chi^2$  statistic from a test of the null hypothesis that the response frequencies do not differ. For no vignette, did certificate condition cause differential response rates.

27. PART I. Enter the diseases, injuries, or complications that caused the death. List only one cause on each line.

|  |   |  |   |  |
|--|---|--|---|--|
| MODE OF DYING (Check appropriate mechanism.) | <input type="checkbox"/> Cardiac arrest     | <input type="checkbox"/> Shock         | <input type="checkbox"/> Exsanguination | Approximate Interval Between Onset and Death |
|  | <input type="checkbox"/> Respiratory arrest | <input type="checkbox"/> Heart failure | <input type="checkbox"/> Other _____    |  |

IMMEDIATE CAUSE (Final disease or condition resulting in death) →

Sequentially list conditions, if any, leading to immediate cause. Enter UNDERLYING CAUSE (Disease or injury that initiated events resulting in death) LAST

a. \_\_\_\_\_  
DUE TO (OR AS A CONSEQUENCE OF):

b. \_\_\_\_\_  
DUE TO (OR AS A CONSEQUENCE OF):

c. \_\_\_\_\_  
DUE TO (OR AS A CONSEQUENCE OF):

d. \_\_\_\_\_

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

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Figure 4. The mode-checkbox version of the cause-of-death section.

*Accuracy of Reported Underlying Cause*

The fictitious nature of the cases made it possible to score each physician's certification according to whether it reported correctly the initiating cause. The principal question addressed by this study was whether the rate at which death is attributed to the correct initiating cause depended significantly on certificate format.

Table 1  
Response Frequencies for Case-Certificate Version Combinations

| Case | Certificate Version |    |     |    | $\chi^2$ |
|------|---------------------|----|-----|----|----------|
|      | I                   | II | III | IV |          |
| A    | 37                  | 37 | 39  | 37 | 0.08     |
| B    | 35                  | 37 | 35  | 43 | 1.15     |
| C    | 37                  | 41 | 38  | 43 | 0.57     |
| D    | 38                  | 42 | 35  | 39 | 0.65     |

Note. Codes for conditions are as follows: I = standard cause-of-death section; II = shaded-line version; III = underlying-cause-box version; IV = mode-checkbox version. Codes for cases are A = diabetes; B = chronic ischemic heart disease; C = smoking; D = lung cancer.

Not all participants completed the special features of the experimental versions, so we developed a protocol that specified from where on each certificate version responses would be taken. The responses summarized in this section were taken from the last-used lines of Part I of the standard, shaded-line, and mode-checkbox versions, and from the extra box of the underlying-cause-box version; if there was no entry in the box, the response analyzed was the last-entered condition in Part I.

Tables 2, 3, 4, and 5 show, for the four vignettes, how many responses corresponded to the correct initiating cause and how many did not. For the *diabetes* case and the *chronic ischemic heart disease* case, for which data are shown in Tables 2 and 3, respectively, the certificate versions did not differ significantly in the effectiveness

Table 2  
Classification of Initiating Cause Responses for Diabetes Case

| Certificate Condition | Initiating Cause Entry |           |
|-----------------------|------------------------|-----------|
|                       | Correct                | Incorrect |
| Standard              | 24                     | 13        |
| Shaded-line           | 29                     | 8         |
| Underlying-cause-box  | 28                     | 9         |
| Mode-checkbox         | 29                     | 10        |

**Table 3**  
*Classification of Initiating Cause Responses for Chronic Ischemic Heart Disease Case*

| Certificate Condition | Initiating Cause Entry |           |
|-----------------------|------------------------|-----------|
|                       | Correct                | Incorrect |
| Standard              | 9                      | 26        |
| Shaded-line           | 15                     | 28        |
| Underlying-cause-box  | 12                     | 25        |
| Mode-checkbox         | 9                      | 26        |

with which they elicited the initiating cause. For the *smoking* case, for which data are shown in Table 4, the formats differed significantly,  $\chi^2(3 \text{ d.f.}) = 8.14, p < .05$ : The underlying-cause-box version was outperformed by the other versions, which did not differ from each other. For the *lung cancer* case, for which data are shown in Table 5, the formats that emphasized the initiating cause (i.e., the shaded-line and underlying-cause-box versions) outperformed the standard and mode-checkbox versions,  $\chi^2(3 \text{ d.f.}) = 12.86, p < .01$ .

A fair conclusion from these data is that reporting of the initiating cause is not enhanced by the mode-checkbox version, and may be helped by a certificate format that emphasizes the initiating cause. For the *diabetes* and *chronic ischemic heart disease* cases, this emphasis did not affect responding; for the *lung cancer* case, the emphasis increased reporting of the initiating cause.

A brief discussion of the anomalous pattern of results for the *smoking* case is warranted. For that case, reporting of the initiating cause on the underlying-cause-box version of the cause-of-death section was worse than

**Table 4**  
*Classification of Initiating Cause Responses for Smoking Case*

| Certificate Condition | Initiating Cause Entry |           |
|-----------------------|------------------------|-----------|
|                       | Correct                | Incorrect |
| Standard              | 19                     | 18        |
| Shaded-line           | 23                     | 20        |
| Underlying-cause-box  | 11                     | 30        |
| Mode-checkbox         | 20                     | 18        |

**Table 5**  
*Classification of Initiating Cause Responses for Lung Cancer Case*

| Certificate Condition | Initiating Cause Entry |           |
|-----------------------|------------------------|-----------|
|                       | Correct                | Incorrect |
| Standard              | 13                     | 25        |
| Shaded-line           | 24                     | 15        |
| Underlying-cause-box  | 26                     | 16        |
| Mode-checkbox         | 11                     | 24        |

on the other versions. The initiating cause for this case was *smoking; chronic obstructive pulmonary disease* had developed, presumably as a result of smoking. A substantial number of the participants who certified this case entered a sequence of conditions in Part I of the certificate that included the subsequence *chronic obstructive pulmonary disease* due to *smoking*, and, in fact, entered *smoking* on the last-used line of Part I of the cause-of-death section. These participants then entered *chronic obstructive pulmonary disease* or *chronic bronchitis* in the underlying-cause box. In other words, the entry in the underlying-cause box, rather than being a deeper cause than the entry on the last-used line of Part I, was a shallower cause.

## References

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## Author Notes

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