New Dimensions in Cause of Death Statistics

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Abstract: This article discusses the limitations of traditional national cause of death statistics. These limitations derive from an attempt to conceptualize a multidimensional phenomenon and reduce down to a unidimensional framework. The article outlines the characteristics of a new multidimensional approach which involves the codification and tabulation of all causes (multiple causes) listed on death certificates. Preliminary data are presented which illustrate that multiple cause of death data do indeed represent a new dimension to cause of death statistics. These data indicate that most major causes of death are contributory factors in many deaths in which they are not the underlying cause of death. For example, in 1976, diabetes mellitus was the underlying cause of approximately 35,000 deaths but was a contributing factor in another 100,000 deaths. This paper also demonstrates the contribution of multiple cause of death data to identifying patterns of association among diseases and the kinds of injuries resulting from various external causes. Finally, data are presented which depict the use of multiple cause data in evaluating the efficacy of the coding rules used to classify the underlying cause of death. (Am J Public Health 1982; 72:1265–1270.)

Introduction

Vital statistics based on causes of death in the United States have been derived traditionally from a unidimensional concept of medical data. Recent research and development activities, however, have opened up avenues to the production of cause of death statistics based on multidimensional concepts. This paper outlines the basis for the unidimensional concept and its advantages and limitations; advocates the multidimensional approach as a major new extension to present data; and presents preliminary data to illustrate this new dimension in cause of death statistics.

Materials and Methods

Underlying Cause of Death: A Unidimensional Approach

The underlying cause of death is defined as “the disease or injury which initiated the train of morbid events leading directly or indirectly to death or the circumstances of the accident or violence which produced the fatal injury.”1 It is selected from an array of conditions given in the cause of death section of the death certificate based on the placement of conditions on the certificate, provisions of the classification structure contained in the International Classification of Diseases, Adapted for Use in the United States (ICDA)2 and selection and modification rules contained in Vital Statistics Instructions for Classifying the Underlying Cause of Death, 1976–1978.3 Selection rules guide the coder in systematically identifying the selected underlying cause of death in terms of both the placement of reported conditions in the predefined certification format and their causal relationships to one another. Modification rules are designed to improve the usefulness of mortality statistics by giving preference to certain classification categories over others and/or consolidating two or more conditions on the certificate into a single classification category provided for by the ICDA.

As a statistical datum, the underlying cause of death is a simple, one dimensional statistic, easy to understand, and in use for many years. Despite these advantages, researchers and administrators in the health field have also recognized its limitations as a statistical basis for conveying comprehensive medical mortality statistics in the United States.4–6. Restricted to one dimension, the underlying cause necessarily prefers certain diseases over others when competition exists among the reported conditions. In some cases the selection—while uniform and standardized—is, in fact, very arbitrary. Thus this process can exclude from statistical tabulations diseases of independent origin which play an important part in initiating the morbid process leading to death.

The underlying cause taps definitionally the initiating condition as opposed to any intervening conditions or the immediate cause(s). This omits information crucial to understanding the overall morbid process and the role each disease plays in it. Much information is lost concerning chronic conditions such as asthma, arthritis, alcoholism, diabetes, and bronchitis which by themselves may not be fatal but which, in combination with another serious disease, may increase the risk of death greatly. Often complications

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of serious diseases are lost in the classification process. Other relevant conditions such as malnutrition, obesity, and personality disorders are overlooked.

Furthermore, the underlying cause of death, when identified through application of the selection and modification rules, frequently differs from that stated by the certifier. The underlying cause of death statistic includes no provision for classifying the nature of injuries. Instead, it is restricted to the external cause of injury.

Multiple Causes: A Multidimensional Approach

Twenty years ago, the limitations of the underlying cause concept and the pressing need for more comprehensive medical data in epidemiological and morbidity research suggested to Dorn, Moriyama, and others that all information in the cause of death certification should be coded, tabulated, and disseminated on an ongoing basis. The Twentieth World Health Assembly defined the causes of death to be entered in the cause of death statement as "all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced any such injuries." These causes, which also include the underlying cause of death, are hereafter referred to as "multiple causes" and constitute the basis for more meaningful cause of death statistics than are presently provided under the underlying cause of death concept.

However, multiple cause of death data should not and, in fact, cannot serve as a replacement for underlying cause of death data. The traditional measure remains essential for trend statistics and comparability with other countries, and is a useful, one dimensional indicator of the condition which triggered the events leading to death. Thus, multiple cause data are seen as a major new dimension to mortality medical statistics, rather than as a substitute measure.

Multiple cause data can contribute to our understanding about the nature of the disease process and death in four areas. First, it is the only information available on the number of deaths in which a given disease is a contributing factor in leading to death. Based on a prior knowledge of the nature of diseases, one would hypothesize that this information would be extremely valuable for many diseases including diabetes, emphysema, bronchitis, pneumonia, and arthritis which are not immediately life threatening or "underlying."

Second, multiple cause of death statistics can provide information about the interaction of diseases leading to death which would otherwise be lacking. Many complex chains of events need to be sorted out to determine conditions which significantly interact with each other as opposed to those which are extraneous to the sequence. We know that an acute myocardial infarction can be caused by arteriosclerosis. Is this relationship empirically verifiable from the perspective of either causality or joint occurrence? To what extent are three-way and four-way interactions among diseases significant?

Third, multiple cause of death data provide information on the nature of the injury sustained in deaths from accidents, poisoning, or violence. We know from underlying cause statistics that approximately 47,000 people die in motor vehicle accidents annually but we do not know how many of these accidents resulted in a fracture, sprain, intracranial injury, internal chest injury, etc. The multiple cause of death data classification process is designed to use both the nature of injury and the external cause sections of the ICDA so that both aspects of the event are recorded in a manner whereby joint analysis of cause and effect can take place.

Fourth, multiple cause of death data provide information on the viability of the rules for underlying cause of death coding and the accuracy of the certification process itself. Because all conditions reported on death certificates are coded, one can compare actual reporting practices with the agreed upon conventions for reporting. For example, one can determine whether certifiers are reporting conditions in an ascending order of causal sequence such that the disease on one line of the certification can cause the disease above it; whether multiple causes are reported on a line in Part I when the guidelines for completion call for only one disease per line; and the extent to which the certifier’s underlying cause (condition reported on the lowest used line of Part I of the certificate) is also the assigned underlying cause.

Data Availability

The first continuing national system for multiple cause of death data production is now in the process of being implemented by the National Center for Health Statistics (NCHS). By late 1982, data from 1968–1978 will be available through public use tapes. Although there have been a few past efforts by states, NCHS, and private groups over the last several decades, none has been as significant in scope or goals as the current program. The present program is based in three major computer systems: ACME, TRAN-SAX, and RETRIEVE. ACME (Automated Classification of Medical Entities) is designed to automatically assign the underlying cause of death to each death record based on codification of each condition reported on the death certificate. TRAN-SAX (Translation of Axis) is designed to translate the axis of classification of the input multiple cause of death data into a form amendable to tabulations and analysis. RETRIEVE (Retrieval of Data) is designed to produce tailor-made tabulations from the data to use in annual core tables, analytical reports, and answering requests for data. The following section presents some of the first data produced by these three joint systems.

Preliminary Data

Table 1 illustrates the tabulation of categories of diseases based on their mention on a death record through presentation of underlying cause and multiple cause frequen-
TABLE 1—Number of Resident Deaths in the United States with Assignment of Selected Causes as the Underlying Cause of Death or as a Multiple Cause of Death and the Ratio of Multiple to Underlying Causes, 1976

<table>
<thead>
<tr>
<th>Disease</th>
<th>ICDA-8 Categories</th>
<th>Number of Deaths Where Disease Is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assigned as</td>
<td>Mentioned as</td>
</tr>
<tr>
<td></td>
<td>the Underlying</td>
<td>a Multiple Cause of Death</td>
</tr>
<tr>
<td></td>
<td>Cause of Death</td>
<td></td>
</tr>
<tr>
<td>Septicemia</td>
<td>038</td>
<td>6,401</td>
</tr>
<tr>
<td>Malignant Neoplasms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*including neoplasms of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lymphatic and hematopoietic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tissues</td>
<td>140–209</td>
<td>377,312</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>250</td>
<td>34,508</td>
</tr>
<tr>
<td>Avitaminoses and other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nutritional deficiencies</td>
<td>260–269</td>
<td>2,619</td>
</tr>
<tr>
<td>Anemias</td>
<td>280–285</td>
<td>3,182</td>
</tr>
<tr>
<td>Diseases of Heart</td>
<td>390–398, 402, 404,</td>
<td>723,878</td>
</tr>
<tr>
<td></td>
<td>410–429</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular Diseases</td>
<td>430–438</td>
<td>188,623</td>
</tr>
<tr>
<td>Arteriosclerosis</td>
<td>440</td>
<td>29,366</td>
</tr>
<tr>
<td>Other diseases of arteries,</td>
<td>441–448</td>
<td>26,432</td>
</tr>
<tr>
<td>arterioles, and capillaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Influenza and Pneumonia</td>
<td>470–474, 480–486</td>
<td>61,866</td>
</tr>
<tr>
<td>Bronchitis, Emphysema, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>490–493</td>
<td>24,410</td>
</tr>
<tr>
<td>Cirrhosis of Liver</td>
<td>571</td>
<td>31,453</td>
</tr>
<tr>
<td>Nephritis and Nephrosis</td>
<td>580–584</td>
<td>8,541</td>
</tr>
<tr>
<td>Certain causes of mortality</td>
<td>760–769.2, 769.4–772,774–778</td>
<td>24,809</td>
</tr>
<tr>
<td>in early infancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms and ill-defined</td>
<td>780–796</td>
<td>30,802</td>
</tr>
<tr>
<td>conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accidents</td>
<td>E800–E949</td>
<td>100,761</td>
</tr>
<tr>
<td>Suicide</td>
<td>E950–E959</td>
<td>26,832</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>1,701,795</td>
</tr>
</tbody>
</table>

* A given death may be counted more than once in this total.

Diabetes mellitus (3.90), influenza and pneumonia (3.16), bronchitis, emphysema, and asthma (2.56), and nephritis and nephrosis (3.07) represent categories in which substantially lower but still high ratios exist. The remaining categories, with the exception of suicide (1.01), have ratios on the order of 1.14–2.00.

In Table 2, a two-way tabulation of the presence or absence of diabetes and nephritis/nephrosis is presented to illustrate the use of multiple cause data in measuring associations between causes. On the assumption of independent occurrence of these diseases, one would expect that diabetes and nephritis/nephrosis would occur together on 1,845 deaths. The combination actually appears on 3,775 deaths—an excess of 100 per cent. If the theoretical framework within which the above analysis is carried out suggests that diabetes might be a sufficient cause of nephritis/nephrosis, a useful measure of the strength of the relationship is Yules Q. * The value of Yules Q ** for this Table is 0.39 (a value of

* The categories are based on condensation of the individual ICDA categories to a standard list of 69 groups as conventionally used in national vital statistics publications; from this list, 17 groups were selected for presentation because they contain a relatively high number (25,000 or more) of multiple cause deaths. The residual category was omitted and some groups were further collapsed before applying the 25,000 criterion. (From unpublished data of the Division of Vital Statistics, NCHS.)

** Q = ad – bc/ad + bc where in a 2 × 2 table, a is the top row, right column frequency; b is the top row, left column frequency; c is the bottom row, right column frequency; and d is the bottom row, left column frequency. This relationship could also be expressed as an odds ratio (1 + Q)/(1 – Q).
1.00 would represent perfect association and a value of 0.00, no association). Thus, one concludes that there is a moderate level of association between these two diseases. This crude analysis must, of course, be extended to other dimensions introducing control variables such as age or sex and additional disease variables to be meaningful. Over time and with an appropriate conceptual framework and methodology, a network or pattern of diseases revolving around diabetes can be established in terms of their relative contribution and interaction in leading to death.

In Table 3, nature of injury and external cause data are presented based on mention of broad categories of each type on death certificates. On approximately 11 per cent of death records (206,434), both a classifiable nature of injury and classifiable external cause are reported. On 1 per cent of the certificates, a classifiable external cause is reported but without a corresponding nature of injury. Accidental deaths (157,961), suicides (26,983), and homicides (19,743) are reported on 76 per cent, 13 per cent, and 9 per cent respectively of the records which have an external cause code reported. Forty-five per cent of the records on which nature of injury codes are assigned contain mention of an adverse effect of a medicinal agent, nonmedicinal agent, or other adverse effect. Fractures, sprains, and dislocations (25 per cent), intracranial injuries (23 per cent), internal injuries (15 per cent), and open wounds (15 per cent) are also assigned on relatively high percentages of records with nature of injury codes. The relationship of nature of injury codes to external cause codes is such that they generally pair with one another in selective combinations. Thus, as shown in Table 3, for records on which a motor vehicle accident is reported as an external cause, a wide range of

### Table 2—Number of Resident Deaths in the United States with Nephritis/Nephrosis and/or Diabetes as a Cause of Death, 1976

<table>
<thead>
<tr>
<th>Nephritis/Nephrosis (580-584) Mentioned</th>
<th>Total</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes Mentioned (250)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>134,505</td>
<td>3,775</td>
<td>130,730</td>
</tr>
<tr>
<td>No</td>
<td>1,774,935</td>
<td>22,418</td>
<td>1,752,517</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,909,440</td>
<td>26,193</td>
<td>1,883,247</td>
</tr>
</tbody>
</table>

### Table 3—Number of Resident Deaths in the United States Tabulated by Mention of an External Cause (E) and Nature of Injury (N), 1976

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No N Code Mentioned</td>
<td># 2,449</td>
<td>1,066</td>
<td>1,108</td>
<td>82</td>
<td>129</td>
<td>72</td>
</tr>
<tr>
<td>% 1.17</td>
<td>2.21</td>
<td>1.01</td>
<td>0.30</td>
<td>0.65</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td>Any N Code Mentioned</td>
<td># 206,434</td>
<td>47,173</td>
<td>108,614</td>
<td>26,901</td>
<td>19,614</td>
<td>7,314</td>
</tr>
<tr>
<td>% 98.83</td>
<td>97.79</td>
<td>98.99</td>
<td>97.97</td>
<td>99.35</td>
<td>98.60</td>
<td></td>
</tr>
<tr>
<td>Fractures, Sprains, and Dislocations (800–848)</td>
<td># 52,101</td>
<td>18,651</td>
<td>30,958</td>
<td>944</td>
<td>1,133</td>
<td>682</td>
</tr>
<tr>
<td>% 24.94</td>
<td>38.66</td>
<td>28.21</td>
<td>3.50</td>
<td>5.74</td>
<td>13.24</td>
<td></td>
</tr>
<tr>
<td>Intracranial Injury (850–854)</td>
<td># 46,523</td>
<td>18,951</td>
<td>10,146</td>
<td>10,273</td>
<td>6,076</td>
<td>1,310</td>
</tr>
<tr>
<td>% 22.27</td>
<td>39.29</td>
<td>9.25</td>
<td>38.07</td>
<td>30.78</td>
<td>25.43</td>
<td></td>
</tr>
<tr>
<td>Internal Injury (860–869)</td>
<td>% 14.60</td>
<td>36.17</td>
<td>4.06</td>
<td>7.52</td>
<td>31.39</td>
<td>13.89</td>
</tr>
<tr>
<td>Lacerations and Open Wounds (870–907)</td>
<td># 30,651</td>
<td>1,793</td>
<td>2,969</td>
<td>15,105</td>
<td>15,228</td>
<td>743</td>
</tr>
<tr>
<td>% 14.67</td>
<td>3.72</td>
<td>2.71</td>
<td>37.62</td>
<td>77.13</td>
<td>14.42</td>
<td></td>
</tr>
<tr>
<td>Superficial Injuries and Contusions (910–929)</td>
<td># 2,307</td>
<td>1,092</td>
<td>947</td>
<td>20</td>
<td>207</td>
<td>70</td>
</tr>
<tr>
<td>% 1.10</td>
<td>2.26</td>
<td>0.86</td>
<td>0.07</td>
<td>1.05</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>Effects of Foreign Body (930–939)</td>
<td>% 5.59</td>
<td>0.74</td>
<td>10.59</td>
<td>0.37</td>
<td>0.82</td>
<td>1.44</td>
</tr>
<tr>
<td>Burns (940–949)</td>
<td># 6,982</td>
<td>1,011</td>
<td>5,408</td>
<td>153</td>
<td>160</td>
<td>255</td>
</tr>
<tr>
<td>% 3.34</td>
<td>2.10</td>
<td>4.93</td>
<td>0.57</td>
<td>0.81</td>
<td>4.95</td>
<td></td>
</tr>
<tr>
<td>Injury to Nerves and Spinal Cord (950–959)</td>
<td>% 2,595</td>
<td>1,159</td>
<td>921</td>
<td>90</td>
<td>390</td>
<td>75</td>
</tr>
<tr>
<td>% 1.24</td>
<td>2.40</td>
<td>0.84</td>
<td>0.33</td>
<td>1.98</td>
<td>1.46</td>
<td></td>
</tr>
<tr>
<td>Other Adverse Effect of Medicinal Agents, Nonmedicinal Substances, or Some Other Adverse Effect (960–999)</td>
<td>% 44.27</td>
<td>35.29</td>
<td>51.60</td>
<td>44.38</td>
<td>22.65</td>
<td>56.94</td>
</tr>
<tr>
<td>TOTAL</td>
<td># 206,434</td>
<td>48,239</td>
<td>109,722</td>
<td>26,983</td>
<td>19,743</td>
<td>5,151</td>
</tr>
<tr>
<td>% 100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>
injuries is reported including fractures, sprains, and dislocations (39 per cent), intracranial injuries (39 per cent), internal injuries (36 per cent), and adverse effects (35 per cent). For non-motor vehicle accidents, two categories outnumber the others in terms of natures of injury. Fractures, sprains, and dislocations are classified on 28 per cent of the records, and 52 per cent of the records contain an adverse effect of either a medicinal agent, nonmedicinal substance, or some other adverse effect. With suicide reporting, nature of injuries frequently include intracranial injuries (38 per cent), open wounds (38 per cent), and adverse effects (44 per cent). For homicides, the pattern is somewhat similar to suicides except that open wounds (77 per cent) predominate the other categories. Also, the relative frequency for internal injuries (31 per cent) is substantially higher and that for adverse effects (23 per cent) is lower.

In Table 4, deaths to United States residents in 1976 are tabulated according to where the assigned underlying cause of death is coded as a multiple cause of death in the medical certification. Since the certifying physician is asked to state the underlying cause of death alone on the lowest used line of Part I, this Table serves as a gross indicator of the level of agreement between the certifier underlying cause and the underlying cause assigned for statistical tabulations. On 55 per cent of the certificates (including those with only one condition), the assigned underlying cause is entered alone on the lowest used line of Part I. On the remaining 45 per cent, it is either found as a specific code in other parts of the medical certification (39 per cent) or cannot be located because the assigned underlying cause represents a combination of more than one entity in the certification (6 per cent). On 13 per cent of the certificates, it is entered on the lowest used line but not alone as stipulated in the instructions for certificate completion. On 22 per cent of the certificates, the underlying cause is entered on an upper line in Part I; and on 4 per cent of the certificates, it is entered in Part II as a contributory condition.

The Table does not shed light on the reasons for these disparities. This will be pursed in further investigation to determine whether they arise from certification problems, inadequacies in the rules for underlying cause selection and modification, or simply differences in perspective and opinion.

Discussion

The statistics contained in the preceding Tables suggest a number of more detailed avenues of inquiry concerning the extent and manner in which conditions other than the underlying cause of death impact on the morbidity train of events leading to death. For example, what is the impact of diabetes in the 100,000 deaths where it is mentioned as a non-underlying cause? Does it accelerate death in a significant manner? Would its elimination have any measurable impact? Is it explosive in combination with certain other diseases such as urinary diseases?

Answers to these questions can be pursued by building a conceptual model based on multi-dimensional causality, then empirically challenging it using multiple cause data, revising the model, subsequently rechallenging it, etc. In this manner, theories concerning mortality causation can be tested, refined, and ultimately used to reduce disease prevalence. A national multiple cause of death statistical program is a vital element in carrying out this activity in an effective manner.

REFERENCES


TABLE 4—Number of Resident Deaths in the United States Tabulated by Location of the ICDU Assigned Underlying Cause of Death in the Medical Certification Section of the Death Certificate

<table>
<thead>
<tr>
<th>Location of Underlying Cause</th>
<th>Number of Deaths</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alone on Lowest Used Line in Part I</td>
<td>1,053,033</td>
<td>55.15</td>
</tr>
<tr>
<td>First Entered on Lowest Used Line in Part I</td>
<td>149,934</td>
<td>7.85</td>
</tr>
<tr>
<td>Other than First on Lowest Used Line in Part I</td>
<td>102,205</td>
<td>5.35</td>
</tr>
<tr>
<td>Upper Line in Part I</td>
<td>419,541</td>
<td>21.97</td>
</tr>
<tr>
<td>Part II</td>
<td>74,080</td>
<td>3.88</td>
</tr>
<tr>
<td>Combination of More than One Entity in Certification</td>
<td>110,647</td>
<td>5.79</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,909,440</td>
<td>100.00</td>
</tr>
</tbody>
</table>

ACKNOWLEDGMENTS

The authors express appreciation to Donna Patten for computer programming support, to June Pearce for nosological assistance, and to Mary Oakley for manuscript preparation. A special expression of appreciation is given to Alice Hetzel, Deputy Director, Division of Vital Statistics, National Center for Health Statistics, for her technical guidance and encouragement in the overall development of the multiple cause of death program described in this article.

American Thoracic Society Annual Meeting
Call for Abstracts


Deadline for submission of abstracts is December 3, 1982. Payment of $25 to cover processing costs must accompany abstract. Abstracts must be submitted in English and should not be submitted if already published or presented at a national meeting prior to the 1983 ATS Annual Meeting. However, papers previously presented at local or regional meetings may be submitted for consideration. Authors of accepted papers will be notified by mid-February 1983.

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