Office of Epidemiology and Scientific Support

Multiple and Underlying Causes of Death using Montana Death Certificates, 1999-2014

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AT A GLANCE

- Two-thirds of death certificates contain more than one cause of death which can be used to explore disease interactions.

- Chronic diseases such as Diabetes and Hypertension have the most number of multiple causes of death.

- Injury surveillance may benefit from multiple cause analysis.

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Introduction

Mortality data is an important source of information for assessing public health. Generally, the initiating disease or condition, referred to as the Underlying Cause of Death, receives the most focus because public health interventions aim to break the sequence of events as early as possible. However, deaths seldom result from a single cause and by limiting reporting to the underlying cause, mortality researchers risk missing important disease interactions. Through examination of each condition listed on the death certificate, multiple cause analysis permits a more comprehensive approach to mortality surveillance and the overall morbid process. This report describes multiple and underlying approaches to mortality statistics using Montana death certificates from 1999 to 2014.

Definitions

The definitions for underlying and multiple causes of death come from the International Classification of Disease (ICD-10) Instruction Manual, 10th revision:[1]

The underlying cause of death is "the disease or injury which initiated the causal chain of morbid events leading directly to death or the circumstances of the accident or violence which produced the fatal injury."

Multiple causes of death include not only the underlying cause but also the immediate cause of death and all other intermediate and contributory conditions listed on the death certificate.

Entity Axis Codes are codes which represent each condition on the certificate in the order and sequence as reported by the certifier.[2]

Record axis codes are entity codes that have been transformed by software according to special rules. This cleaning process removes redundant conditions and may combine multiple conditions into one composite condition.[2]

Certifying and Coding the Death Certificate (Figure 1)

The death certificate consists of an upper portion containing the personal information of the decedent and a lower portion describing the circumstances of death. The certifier, the person completing the lower portion of the death certificate, can be a physician, mid-level practitioner, or coroner, whereas the upper portion is typically completed by a funeral director. The cause of death section lies within the medical portion of the death certificate and is divided into two parts. Part I is to record the chain of events leading to death, proceeding backwards from the final disease or condition. In this manner, each cause leads to the condition listed on the line above.

Part II contains information on the diseases and conditions which contributed to death but not part of the causal chain of events leading to the Underlying Cause of Death.[3] Using figure 1 as an example, the certifier reported hypertension in part II because in their opinion coronary artery disease leading to an acute cardiac infarction with rupture of the cardiac muscle best described the sequence of events leading to death. Although hypertension is a serious cardiovascular disease, its role was thought to be more contributory to the morbid process.

The process of completing parts I and II of the death certificate varies in complexity. Several sources of documentation are available to assist medical examiners and physicians in completing the certificate.[3,4,5]These manuals are also a valuable source of information for mortality researchers wishing to better understand death certification.

The completed death certificate is sent to the National Center for Health Statistics (NCHS) for automated medical coding and any records that the computer cannot code are manually coded by trained NCHS nosologists. NCHS processes every written condition and contributing factors and assigns each a code based on ICD-10. Mortality statistics limit the ICD-10 code to four characters with the first being a letter. The letter corresponds to one of 22 chapters of major disease classifications and the remaining digits refer to specific conditions in increasing detail.[1]

Next, the system selects the condition that best describes the initiating disease process or underlying cause of death based on a series of decision tables. A second computer program then creates the multiple cause data which is separated into two forms, Entity Axis Codes and Record Axis Codes.[6] Entity axis codes are created from the statements as they are listed on the certificate without modification. In this manner, entity axis coding preserves all the original information and its sequence on the certificate. Record axis coding is a transformed version of the entity axis codes. The entity codes are examined for contradictions, duplications, or other inconsistencies while an automated process applies corrections which may combine or eliminate certain conditions. In the process, record axis codes lose information on the position and sequence of the entity codes but gain a better representation of the disease process. [7]

Figure 1: Overview of the Underlying and Multiple Cause of Death Coding Process
Source: MT Vital Statistics—Fictitious Example

Step 1: The completed certificate is sent to NCHS

CAUSE OF DEATH (See instructions and examples)	Approximate interval: Onset to death

32. **PART I.** Enter the chain of events--diseases, injuries, or complications--that directly caused the death. DO NOT enter terminal events such as cardiac arrest, respiratory arrest, or ventricular fibrillation without showing the etiology. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.

IMMEDIATE CAUSE (Final disease or condition ------> resulting in death)
a. Rupture of myocardium _____ Minutes
   Due to (or as a consequence of):

Sequentially list conditions, if any, leading to the cause listed on line a. Enter the
b. Acute myocardial infarction _____ 6 days
   Due to (or as a consequence of):

UNDERLYING CAUSE (disease or injury that initiated the events resulting in death) **LAST**
c. Coronary artery disease _____ 5 years
   Due to (or as a consequence of):

d. _____

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

Hypertension

33. WAS AN AUTOPSY PERFORMED? ■ Yes ☐ No
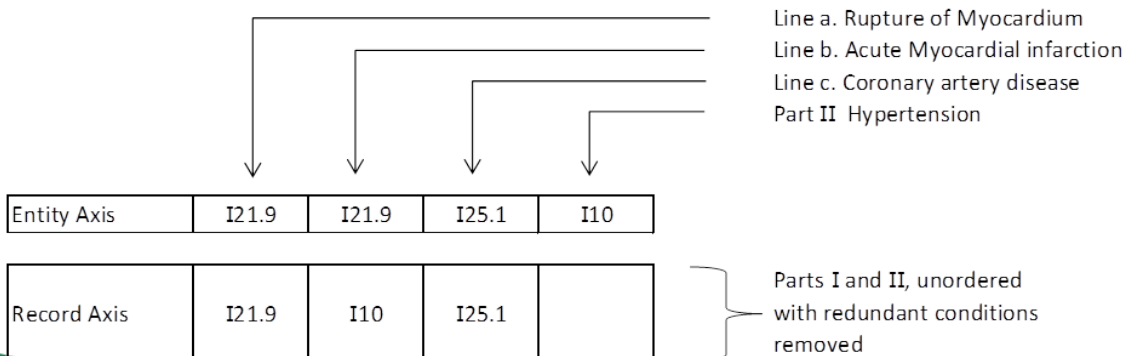34. WERE AUTOPSY FINDINGS AVAILABLE TO COMPLETE THE CAUSE OF DEATH? ■ Yes ☐ No

Step 2: Each written line is converted to an ICD-10 code

I21.9	Acute Myocardial Infarction, unspecified				
Categories				Sub-Category	
I	2	1	.	9	
Diseases of the Circulatory System	Ischemic heart diseases	Acute myocardial infarction		Acute myocardial infarction, unspecified	

Step 3: Assign an underlying cause of death

I21.9

Step 4: Multiple cause coding creates two lists of codes for statistical analysis

Line a. Rupture of Myocardium
Line b. Acute Myocardial infarction
Line c. Coronary artery disease
Part II Hypertension

Entity Axis	I21.9	I21.9	I25.1	I10

Record Axis	I21.9	I10	I25.1	

Parts I and II, unordered with redundant conditions removed

Methods

Data used in this report come from the Montana Office of Vital Records and were restricted to all deaths occurring within the state from 1999 to 2014. A total of 112,239 death certificates were included in this analysis. Underlying Causes of Death were determined from the underlying cause of death codes provided by NCHS. Non-underlying multiple causes of death were ascertained using record axis codes coded according ICD-10. The list of 15 Leading Causes of Death published by the National Center for Health Statistics were used in the comparisons between underlying and multiple causes of death. [8] For the Underlying Causes of Death, underlying causes of death corresponding to the 15 Leading Causes were tabulated and ranked. For the multiple causes of death, every mention of any of the 15 leading causes were tabulated and ranked. Both were expressed as absolute count and percent of deaths. [9,10]

Results

Nearly sixty percent (n=60,809) of death certificates listed one or two causes while the remaining certificates (n=45,430) reported three or more causes of death (Table 1).

Table 1 Frequency and Percent of Causes of Death by Reported Causes
Source: MT Vital Statistics, 1999-2014

Number of Causes Per Death	Number of Certificates	Percent of Certificates
1	36,589	32.6
2	30,220	26.9
3	20,314	18.1
4	11,973	10.7
5	6,319	5.6
6	3,333	3.0
7	1,713	1.5
8 ≤	1,778	1.6
Total	112,239	100.0

When comparing the 15 Leading Causes of Death determined by Underlying Cause of Death and determined by Multiple Cause of Death, the ranking for the first four conditions were nearly the same with only the order for malignant neoplasms and diseases of the heart reversed.

Accidents, Alzheimer's disease, influenza and pneumonia, suicide, chronic liver disease and cirrhosis, and Parkinson's disease moved lower in rank using Multiple Cause of Death, whereas the multiple cause rank for diabetes mellitus, nephritis, and pneumonitis moved slightly higher. The rank for essential hypertension increased the most out of all conditions—moving from 15th place in the underlying cause list to 6th place using the multiple cause approach (Table 2).

Table 2: Comparison of the 15 Leading Causes of Death using Underlying and Multiple Causes of Death
Source: MT Vital Statistics 1999-2014.

Underlying Causes of Death	Underlying Cause of Death		Multiple Cause of Death	
	Rank	Number	Rank	Number
Malignant Neoplasms	1	29,379	2	31,312
Diseases of the Heart	2	24,938	1	39,973
Chronic lower respiratory diseases	3	6,555	3	13,039
Cerebrovascular Disease	4	6,075	4	9,939
Accidents	5	4,922	8	7,077
Alzheimer's Disease	6	3,595	10	4,567
Diabetes mellitus	7	3,590	5	8,613
Influenza and Pneumonia	8	2,346	9	6,938
Intentional self-harm (suicide)	9	1,960	14	1,967
Chronic Liver Disease and Cirrhosis	10	1,404	13	2,173
Nephritis, nephrotic syndrome, and nephrosis	11	1,351	7	7,296
Septicemia	12	1,220	11	3,396
Parkinson's disease	13	1,101	15	1,606
Pneumonitis due to solids and liquids	14	786	12	2,644
Essential hypertension and hypertensive renal disease	15	686	6	8,426

Multiple cause analysis can also be used to explore the interactions or presence of other non-underlying causes of death when selected using an underlying cause of death code. For example, it is known that the progression of diabetes leads to diseases of the heart, kidney, nerves and blood vessels.[11] Using the example, researchers could determine both the absolute count of non-underlying causes associated with diabetes and the frequency of those conditions reported on the death certificate.

When simply examining the number of multiple causes reported by leading underlying cause, hypertension, diabetes, accidents, and kidney disease have an average of four or more conditions reported on the death certificate. Cancer, Alzheimer's disease, and suicide have the fewer than 3 causes of death reported per certificate while the remaining leading causes averaged around 3 reported causes (Table 3).

Table 3: Average Number of Multiple Causes Reported on the Death Certificate by
Underlying Leading Cause of Death
Source: MT Vital Statistics 1999-2014

Underlying Causes of Death	Average Number of Multiple Causes Reported
Essential hypertension and hypertensive renal disease	4.5
Diabetes mellitus	4.2
Accidents	4.1
Nephritis, nephrotic syndrome, and nephrosis	4.0
Septicemia	3.9
Chronic lower respiratory diseases	3.8
Pneumonitis due to solids and liquids	3.7
Diseases of the Heart	3.2
Chronic Liver Disease and Cirrhosis	3.2
Influenza and Pneumonia	3.1
Cerebrovascular Disease	3.0
Parkinson's disease	3.0
Intentional self-harm (suicide)	2.9
Alzheimer's Disease	2.6
Malignant Neoplasms	2.2

Discussion

The comparison of underlying and multiple cause analysis demonstrates the variability in the certifying process. Nearly two-thirds of all death certificates had more than one condition reported. However, the remaining third of certificates reported only a single cause and therefore the multiple cause approach would fail to provide any additional information.

Not surprising, chronic diseases with well-established co-morbidities averaged four or more reported conditions per death certificate. While the presence of multiple conditions in deaths attributed to chronic disease may be anticipated, it also provides an opportunity to examine the interactions of the additional causes on the underlying disease of interest and track those interactions over time.

Unintentional injuries or accidents were also associated with an average of four or more reported conditions. Unlike chronic conditions, with accidents the chain of events leading to death usually occurs rapidly rather than developing over time. In these cases, multiple cause analysis may still produce useful information on the frequency of certain injuries and the type of body systems impacted. This combined with the description of injury, listed elsewhere on the certificate, has the potential of complementing the study of unintentional injuries.

Underlying and multiple cause analysis have certain limitations. The death certificate does not represent a complete medical record and causes of death represent a medical opinion that might vary among physicians and may be limited by medical training, access to medical records, or laboratory and autopsy results.[12] The information reported on the certificate also varies by certifier and the extent they document the event. In some cases, the cause of death may be difficult to determine. As Custis and Schwartz noted, the absence of cause of

death or contributing information on the death certificate does not mean "No." It is missing data and must be treated as such.[13] Other limitations with using the information contained on the death certificate are reported elsewhere.[14,15]

Changing patterns in mortality statistics with populations transitioning away from infectious diseases towards more chronic conditions, further underscore the need to supplement our approach to mortality surveillance.[16] Using the multiple cause approach in addition to traditional mortality surveillance greatly enhances our ability to understand the overall morbid process and develop more comprehensive public health interventions that target these processes.

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