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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

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, 10<sup>th</sup> revision:<sup>1</sup>

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.<sup>2</sup>

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.<sup>2</sup>

#### 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.

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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.<sup>3</sup> 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.<sup>3,4,5</sup> 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.<sup>1</sup>

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.<sup>6</sup> 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.<sup>7</sup>

Figure 1: Overview of the Cause 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:<br>Onset to death   |
|--|--|---|
| 32. <b>PART I.</b> Enter the <u>chain of events</u> —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.<br><br>IMMEDIATE CAUSE (Final disease or condition -----> resulting in death) a. <u>Rupture of myocardium</u><br>Due to (or as a consequence of):<br><br>Sequentially list conditions, if any, leading to the cause listed on line a. Enter the <b>UNDERLYING CAUSE</b> (disease or injury that initiated the events resulting in death) <b>LAST</b> b. <u>Acute myocardial infarction</u><br>Due to (or as a consequence of):<br><br>c. <u>Coronary artery disease</u><br>Due to (or as a consequence of):<br><br>d. _____ |  | Minutes<br><br>6 days<br><br>5 years<br><br>_____   |
| 33. <b>PART II.</b> Enter other <u>significant conditions contributing to death</u> but not resulting in the underlying cause given in PART I<br>Hypertension  |  | 33. WAS AN AUTOPSY PERFORMED?<br><input checked="" type="checkbox"/> Yes <input type="checkbox"/> No<br>34. WERE AUTOPSY FINDINGS AVAILABLE TO COMPLETE THE CAUSE OF DEATH? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |

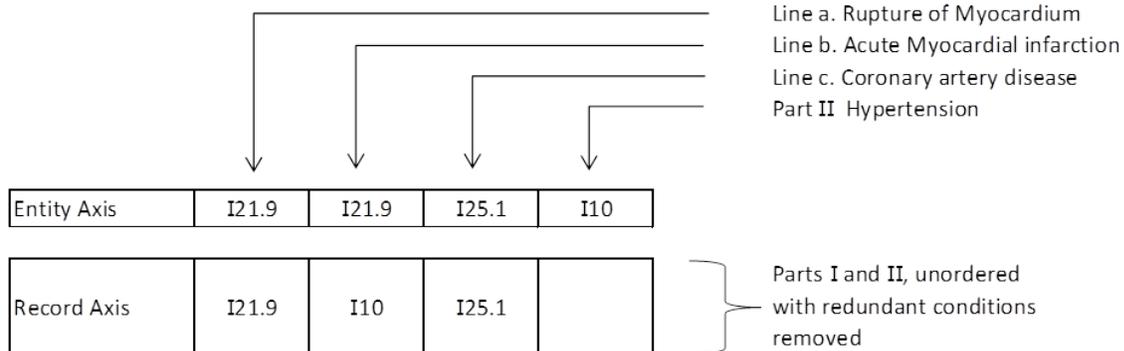
Step 2: Each written line is converted to an ICD-10 code

|                                    |  |                             |   |  |
|------------------------------------|--|-----------------------------|---|--|
| 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



## 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.<sup>8</sup> 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.<sup>9,10</sup>

## 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 15<sup>th</sup> place in the underlying cause list to 6<sup>th</sup> 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 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.<sup>11</sup> 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

|   | 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.<sup>12</sup> 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.”<sup>13</sup> Other limitations with using the information contained on the death certificate are reported elsewhere.<sup>14,15</sup>

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.<sup>16</sup> 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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<sup>1</sup> World Health Organization. International Statistical Classification of Diseases and Related Health Problems-10<sup>th</sup> Revision (5 ed.).2016. Geneva, Switzerland: WHO Press.

<sup>2</sup> Minino, A. Coding and Classification of Causes of Death in accordance with the Tenth Revision of the International Classification of Disease. [PowerPoint Slides] Accessed at: [http://www.cdc.gov/nchs/ppt/nchs2012/LI-14\\_MININO.pdf](http://www.cdc.gov/nchs/ppt/nchs2012/LI-14_MININO.pdf) on Nov 18, 2015

<sup>3</sup> Centers for Disease Control and Prevention, National Center for Health Statistics. Physician’s Handbook on Medical Certification of Death (2003 ed.). 2004. Hyattsville, Maryland: US Department of Health and Human Services.

<sup>4</sup> Centers for Disease Control and Prevention, National Center for Health Statistics. Medical Examiners’ and Coroners’ Handbook on Death Registration and Fetal Death Reporting (2003 ed.). 2003. Hyattsville, Maryland: US Department of Health and Human Services.

<sup>5</sup> Centers for Disease Control and Prevention, National Center for Health Statistics. The Autopsy, Medicine, and Mortality Statistics S3:No32. 2001. Hyattsville, Maryland: US Department of Health and Human Services.

<sup>6</sup> Centers for Disease Control and Prevention, National Center for Health Statistics. ICD-10 Mortality Manual 2b. 2014. A, Maryland: US Department of Health and Human Services.

<sup>7</sup> Wall M., et al. Factors Associated with Reporting Multiple Causes of Death. BMC Medical Research Methodology. 2005;5(4).

<sup>8</sup> Centers for Disease Control and Prevention. Deaths: Final Data for 2013. National Vital Statistics Report 2014;64(2).

<sup>9</sup> Israel, R., Rosenberg, H. and Curtin, L. Analytical Potential for Multiple Cause of Death Data. American Journal of Epidemiology. 1986;124(2):161-179

<sup>10</sup> Redelings, M, Sorvill, F. and Simon, P. A Comparison of Underlying Cause and Multiple Causes of Death: US Vital Statistics 2000-2001. Epidemiology. 2006; 17(1) :100-103

<sup>11</sup> Gæde, P. et al. Multifactorial Intervention and Cardiovascular Disease in Patients with Type 2 Diabetes. New England Journal of Medicine. 2003; 348(5): 383-393

<sup>12</sup> Centers for Disease Control and Prevention, National Center for Health Statistics. Possible Solutions to Common Problems in Death Certification. 1997. Accessed at: [http://www.cdc.gov/nchs/nvss/death\\_certification\\_problems.htm](http://www.cdc.gov/nchs/nvss/death_certification_problems.htm)

<sup>13</sup> Custis, C. and Schwartz, B. Reading the Literals: Searching for Expressions in the Text on Death Certificates in Montana, 2003-2010. Montana Department of Health and Human Services. 2012. Available at: [http://dphhs.mt.gov/Portals/85/publichealth/documents/Epidemiology/MTHDDS/Surveillance%20Reports/ReadingtheLiterals\\_SearchingforExpressionsinTextonDeathCertificates.pdf](http://dphhs.mt.gov/Portals/85/publichealth/documents/Epidemiology/MTHDDS/Surveillance%20Reports/ReadingtheLiterals_SearchingforExpressionsinTextonDeathCertificates.pdf)



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<sup>14</sup> Messite, J and Stellman, S. Accuracy of Death Certification Completion: The Need for Formalized Physician Training. *Journal of the American Medical Association*. 1996;275(10):794-796.

<sup>15</sup> Sehdev, A. and Hutchins. Problems with Proper Completion and Accuracy of the Cause of Death Statement. *Archives of Internal Medicine*. 2001;161:277-284

<sup>16</sup> Moriyama IM, Loy RM, Robb-Smith AHT. *History of the Statistical Classification and Causes of Death*. Hyattsville, Maryland: National Center for Health Statistics